National Park Service Inventory and Monitoring Program

Northeast Coastal and Barrier Network Monitoring Plan

Phase I

Sara M. Stevens and Bryan Milstead

Data Manager and Network Coordinator
University of Rhode Island
105 Coastal Institute in Kingston
Kingston, RI 02881
Sara_Stevens@nps.gov
Bryan_Milstead@nps.gov

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ESTABLISHMENT OF THE SERVICEWIDE INVENTORY AND MONITORING (I&M) PROGRAM

For most of the 20th century, the National Park Service has practiced a curious combination of active management and passive acceptance of natural systems and processes, while becoming a superb visitor services agency. In the 21st century that management style clearly will be insufficient if park natural resources are to be preserved in a "pristine" state. Protection of park natural resources now requires active and informed management to a degree unimaginable in 1916 when the Park Service was first established. The lack of information today about park plants, animals, ecosystems, and their interrelationships is profound.

In 2000, Congress wrote *"The Committee applauds the Service for recognizing that the preservation of the diverse natural elements and the great scenic beauty of America's national parks and other units should be as high a priority in the Service as providing visitor services. A major part of protecting those resources is knowing what they are, where they are, how they interact with their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data."*

In 1998 the National Parks Omnibus Management Act was passed by Congress mandating that all park managers know the condition of natural resources under their stewardship and to monitor long-term trends in those resources in order to fulfill the NPS mission of conserving unimpaired park lands. Title II of the Act explicitly directs the National Park Service to use a broad program of the highest-quality science and information in managing and protecting units of the national park system. In response to the Omnibus Management Act, the Park Service undertook several important steps to integrate this language into its revised management policies, released in December 2000 (*NPS Management Policies 2001)*. The 2001 policies state that the Service will:

- Identify, acquire, and interpret needed inventory, monitoring, and research, including applicable traditional knowledge, to obtain information and data that will help park managers accomplish park management objectives provided for in law and planning documents.
- Define, assemble, and synthesize comprehensive baseline inventory data describing the natural resources under its stewardship, and identify the processes that influence those resources.
- Use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals.
- Analyze the resulting information to detect or predict changes, including interrelationships with visitor carrying capacities, that may require management intervention, and to provide reference points for comparison with other environments and time frames.

In 1999, the Natural Resource Challenge was announced as the "National Park Service's Action Plan for Preserving Natural Resources". This action plan represents a strong commitment to preserving natural resources in the parks and requiring that active and informed management be based on sound science. The plan addresses the need to expand existing inventory programs and develop efficient ways to monitor the vital signs of natural systems through the Service's Inventory and Monitoring Program.

A successful program should provide answers to questions such as; What is the condition of park resources? How is the condition of our resources changing over time? What is the condition of

resources outside of park boundaries (air, water, nonnative and migratory species)? What impact do these resources have on park resources and what are the implications of these findings to parks and to the larger systems in which they reside? and finally, what actions need to be taken for preserving these resources?

With the establishment of the Inventory and Monitoring Program (I&M Program), goals and objectives were set for vital signs monitoring (ecosystem monitoring) in Networks with biogeographically similar parks. These goals are as follows:

- Determine status and trends in selected indicators of park ecosystem health to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
- Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
- Provide a means of measuring progress towards performance goals

As part of the I&M Program, 32 Networks of 272 parks, have been established and tasked with developing and implementing network-wide, long-term ecological monitoring programs that meet these Servicewide goals.

THE NORTHEAST COASTAL AND BARRIER NETWORK

The Northeast Coastal and Barrier Network includes eight National Park Service sites across five states. Extending from the Cape Cod National Seashore in Massachusetts to the Colonial National Historical Park in Virginia, the Coastal and Barrier Network is one of the 32 I&M Networks (Table 1). These parks represent some of the most ecologically similar collections of lands within the Park Service. They consist of critical coastal habitat for many rare and endangered species, as well as migratory corridors for birds, sea turtles and marine mammals. They also protect vital coastal wetlands, essential to water quality, fisheries, and the biological diversity of coastal, nearshore, and terrestrial environments.

Table 1. Park Members of the Coastal and Barrier Network.

Park Name	Code	Location	Hectares	Acreage
Assateague Island National Seashore	ASIS	MD,VA	19,200	48,000
Cape Cod National Seashore	CACO	MA	17,442	43,604
Gateway National Recreation Area	GATE	NY, NJ	10,644	26,610
Fire Island National Seashore	FIIS	NY	7,832	19,580
Colonial National Historical Park	COLO	VA	3,740	9,350
George Washington Birth Place NM	GEWA	VA	220	550
Thomas Stone National Historic Site	THST	MD	129	322
Sagamore Hill National Historic Site	SAHI	NY	33	83

As part of the Atlantic coastline, parks in the Northeast Coastal and Barrier Network represent islands of protected lands within the urban sprawl of the Northeast. Sixteen percent of the entire United States

population resides in the coastal zone (Culliton, et al. 1990). Census estimates indicate that populations residing within this zone are growing three times the rate of the total United States population (Culliton et al. 1989). Without scientifically based knowledge and information on the effects of urban pressure on the health of these park ecosystems, it is uncertain that current management decisions are being made that maintain or restore ecosystem health in these parks. Developing a long-term monitoring program is fundamental to the protection and management of their natural resources. Key components in developing a structured monitoring program for the Network include data collection, information management, preparation of data summaries and interpretive reports, feedback to management, and program coordination and support.

Assateague Island National Seashore (ASIS)

Assateague encompasses more than 19,000 hectares, more than half of which consists of oceanic and estuarine waters surrounding the Island (Figure 1). Located within a three-hour drive of the Washington/Baltimore/Philadelphia metropolitan area, the National Seashore hosts more than 1.8 million visitors every year. Assateague Island consists of three major public areas. Approximately 26,000 acres of this island are located in Maryland. The state of Maryland manages a section of the northern part of the island called Assateague State Park and the NPS manages the remainder of the Maryland portion of the island as Assateague Island National Seashore. The Virginia section of the island is managed by the U.S. Fish and Wildlife Service as Chincoteague National Wildlife Refuge. The northern 10 km of ASIS called the "north end", is managed as a primitive area where public access is limited to foot and boat-in traffic. Vehicle traffic is restricted to NPS beach patrols and authorized research activities. The 3.2 km section of the island immediately south of Assateague State Park is managed by ASIS as a developed recreational area and includes campgrounds, day-use facilities and interpretive trails. The 19 km section south of the developed area to the MD/VA state line is managed as a primitive and traditional recreation area, which permits off-road vehicle (ORV) use, back-country camping and hunting. Off-road vehicle use is restricted to the ocean beach and other designated trails west of the ocean beach.

The park's natural resources include a diverse assemblage of aquatic and terrestrial wildlife, including the free-roaming feral horses for which Assateague is famous. The vegetation communities, geological features and physical processes reflect the complexity of the land/sea interface along the Mid-Atlantic coast. The indigenous plant communities at ASIS reflect the adaptive extremes necessary for survival on a barrier island, where exposure to salt spray, lack of freshwater, and shifting sands create a harsh and dynamic environment.

Changing patterns in land use within the watershed of the coastal lagoons of ASIS threatens park water quality and biotic systems. Although park waters are considered to be in "good" condition at present, nearby estuaries with more extensive development are significantly degraded, primarily due to nutrient enrichment from anthropogenic nutrient inputs. With a projected growth rate of >20% in land development over the next 25 years, the potential for similar degradation of park waters is considered high. The ability to document changing estuarine conditions, including trends in submerged aquatic vegetation, fish, and benthic invertebrate community composition, is considered crucial towards influencing and mitigating local/regional development.

Since 1935, the federal navigation channel at Ocean City, MD has disrupted the natural sediment supply to Assateague Island, resulting in wholesale physical and biological changes. A comprehensive mitigation program has been developed involving both short term (one-time beach nourishment) and long term components (sediment bypassing). Implementation and management of these programs will require the ability to continuously evaluate island conditions, (including changes in the distribution and

abundance of rare species), relevant physical processes, and the effects of restoration actions in order to optimize outcomes and ensure maximum compatibility with management objectives.

Portions of ASIS provide suitable habitat for a variety of state and federally listed species, both plants and animals. The known and perceived threats to these species vary in intensity, and include a range of causative factors such as; recreational activities, disruptions to natural coastal processes, and interactions with both native and non-native species. Certain high-profile species such as the piping plover are being actively managed, but others remain poorly understood and are largely ignored. In particular, rare resident plant and insect species, and transient bird species lack appropriate levels of documentation (presence/absence, distribution and abundance), threat mitigation, and assessment.

Non-native plant (especially Phragmites and Asiatic sand sedge) and animal species (feral horses, sika deer, nutria) present on Assateague Island are known to be having a significant impact on several of the primary vegetation communities occurring within the park. Documented effects include reduced health and reproductive capacity of certain key plant species, changes in species abundance and community composition, and loss of faunal biodiversity. The development of long-term management programs to mitigate the impacts of these species requires a variety of basic life history, distribution, and relative abundance data to guide decision-making and program implementation/evaluation. The following list include some of Assateague's current natural resource management issues.

- **Estuarine Water Quality** and its affect on the distribution and abundance of submerged aquatic vegetation (SAV's).

- **Altered coastal processes** and its affects on early successional, disturbance-driven beach habitat, and associated plant/animals.

- **Exotic Species** and their impacts on native species and rare/sensitive habitats

- **Recreational Activities** and their impacts on migratory shorebirds using ocean beach as "stopover habitat" as well as the ocean nearshore benthic macroinvertebrate community.

- **Adjacent land use changes** and associated water quality issues.

Figure 1. Assateague Island National Seashore Visitor Map

Cape Cod National Seashore (CACO)

Cape Cod National Seashore preserves approximately 17,442 hectares of uplands, wetlands and tidal lands located on Outer Cape Cod, Massachusetts. A mosaic of natural and cultural resources, which are the result of dynamic natural processes and at least 9,000 years of human activity, characterizes CACO (figure 2).

The natural terrain contains an exceptional array of coastal communities, including pitch pine/oak forest, heathlands (nearly the entire eastern U.S. distribution of heathlands is restricted to fragments on the Outer Cape and in coastal Maine), dunes and coastal plain pond shores. There is also a wide diversity of aquatic and marine habitats, such as kettle ponds, cedar swamps, vernal pools), drowned river valley salt marshes, back barrier salt marshes, barrier spits and inter-tidal mudflats. These habitats support numerous state, federal, and globally rare, threatened, and endangered species of plants, invertebrates, and vertebrates. For many, CACO provides some of the best quality remaining habitat and offers prime opportunities for their preservation regionally. The great Outer Beach also provides outstanding examples of dynamic geomorphic processes.

During the past three centuries Cape Cod ecosystems have been profoundly altered by human occupation. For example, construction of dikes and roadways in estuaries has changed natural tidal regimes and resulted in degradation of water quality and loss of native plant and animal species. Beach and dune stabilization efforts have interfered with natural morphological processes on shorelines. Discharges from nonpoint sources of pollution such as landfills, septic systems, and golf courses have adversely affected surface and groundwater quality. Fire suppression has altered the distribution and volume of the heathland and pitch pine communities that predominated before European settlement. Some of the highest ozone levels in the northeast have been recorded at CACO. Municipal and private in-holdings and over 5 million visitors annually create a formidable challenge to protection and management of natural resources.

Over 800 species of plants are extant in CACO in a wide range of community types including heathlands, fresh and salt water wetlands, tidal marshes, upland forests, beaches, dunes and grasslands. CACO's natural resource management program faces a number of increasingly complex and challenging issues. The following is a list of some of CACO’s top management issues.

Cape Cod National Seashore Natural Resource Management Issues.

- **Aquatic/Estuarine Issues** include: cultural nutrient enrichment of Kettle Ponds and Salt Marsh, Historic Diking of Salt Marshes and need for restoration, Mosquitoes and Political Pressure for Mosquito Management, Groundwater Withdrawal and impacts to wetland vegetation and animal life, recreational trampling of kettle pond, shoreline vegetation, Horseshoe Crab Harvesting

- **Development Associated Issues include:** Residential Development within and especially immediately adjacent to the park, leading to: Habitat Fragmentation and increases in road kills, increased pet predation on native wildlife, groundwater withdrawal and septic inputs, increased levels of human activity/disturbance within the park.

- **Landscape/Vegetation Issues include:** Landscape significantly altered by Europeans over nearly 4 centuries. Much of vegetation is a post-agrarian mix of native and alien species, Alien species dominate in many places, Even in native dominated vegetation, community structure does not represent natural condition, Fire suppression impacts, Loss of grassland/heathland habitats-determining relative amounts that were natural versus anthropogenic.

- **Recreational Impacts include:** Numerous social trails/trampling of vegetation/mountain bike trails, Jet Skis, Pets off leash/hunting dogs, releasing non-native pheasants for put/take hunting, trampling of dune vegetation.

- **Preservation of Native Species Biodiversity include:** Determining extent to which all of the issues listed above contribute to this issue, except for federal listed species, status and distribution of most state-listed species is unknown, out of date, incomplete. Many other species of formerly common species appear to be declining. Data on their status and distribution are lacking. Others appear to have disappeared in recent years. Loss of heathland grassland habitat and declines in associated wildlife species.

- **Shoreline Dynamics include**: Accelerated rates of erosion due to recreational impacts dredging/deposition of spoil

Figure 2. Cape Cod National Seashore Visitor Map

Colonial National Historical Park (COLO)

Colonial National Historical Park's 3,740 hectares are within the coastal plain of Tidewater Virginia (Figure 3). The park consists of two significant land holdings, the Yorktown and Jamestown units, connected by a narrow traffic corridor, called the Colonial Parkway. The park is located adjacent to a rapidly developing urban/suburban area. The entire park has a direct hydrological link to the Chesapeake Bay. Most of the park extends along either the York or James Rivers, two of the largest rivers contiguous to the western shore of the Chesapeake Bay. In addition, numerous streams, creeks and ponds flow through the park and feed directly into one of these two rivers. Mixed pine and hardwood forests cover most of the park. Substantial acreage of both tidal and nontidal wetlands and open fields also exist. The park is within the boundaries of the counties of York, James City, Gloucester, Surry, the City of Williamsburg and Virginia Beach.

More than 30 miles of shoreline along the James and York rivers bounds the park. In addition, approximately 24 miles of perennial streams and 30 miles of intermittent streams and drainage's flow through the park. Numerous freshwater tributaries in Yorktown become tidally influenced estuarine waters as they approach the James and York rivers. The Colonial Parkway passes among upland and tidal streams as well as freshwater and brackish ponds. A freshwater spring and a small creek are found at Green Spring plantation and a series of springs and seeps originate on Yorktown Battlefield. Numerous ephemeral sinkholes occur in the Yorktown Battlefield and along the Parkway between Yorktown and College Creek. Preliminary findings indicate generally good water quality in most surface waters within the park. However, some streams are impaired based on analysis of physical attributes and benthos. Most of the water bodies and wetlands in the park have major portions of their drainage basin upstream and outside of park boundaries. Therefore, activities outside of the park have a detrimental effect on water quality within the park (oil spills, erosion and sedimentation, chemicals).

Erosion is a significant process along the river shorelines of the park. Although much of the erosion results from normal and storm induced wave activity, impacts resulting from recreational use have become a concern. Shoreline recession threatens the cultural resources of Jamestown Island, Glasshouse Point and Yorktown. The park in cooperation with the Virginia Institute of Marine Science and the US Army Corp of Engineers conducted a study of the 17 miles of park shoreline along the James River. The study has provided a better understanding of the shoreline erosion process over the past decades, those areas experiencing the highest erosion rates and recommendations (with alternatives) for conserving the shoreline and its associated cultural and natural resources. A cost benefit analysis has been completed and approved. Major funding has been procured and an EIS is being prepared.

The park, in cooperation with researchers from the Virginia Institute of Marine Science conducted a study to investigate the effects of adjacent urban and agricultural development on the shallow groundwater and selected surface water resources of the park. Testing indicates potential local sources of groundwater contamination from nitrate and ammonia at several sites near Jamestown Island, Williamsburg and Yorktown. Salinity and phosphate concentrations were low or below detectable levels. The US Geological Survey, USGS is conducting a study to develop the hydrogeological framework of the Yorktown area of the park and surrounding environs.

The biological resources of Colonial NHP include a variety of birds, fish, mammals, aquatic invertebrates, plants and wetlands typical of the mid-Atlantic Coastal Plain. None of these resources is limited to the park, but parklands provide important habitat within the larger geographic area. The park contains significant aquatic habitats within the tidal systems found along the shores of the York and

James rivers and in most of the tidal creeks to those rivers. In addition, freshwater streams and ponds in the Yorktown unit and along the Colonial Parkway support a number of freshwater aquatic communities. Protection of these aquatic communities is also important because the park provides unique opportunities for public observation, education and recreational fishing. The roadways and access areas throughout the park afford opportunities for close examination of wetlands and waterfowl as well as opportunities for swimming fishing and shellfishing.

According to studies by the Virginia Department of Conservation and Recreation, Division of Natural Heritage Colonial NHP has the second highest number of rare threatened and endangered species of all the National Park Service units in the state. The inventory reports indicate the importance of parklands and areas adjacent to the park. The Division of Natural Heritage has recently completed a detailed management plan for these species and habitats. The following is a list of current park management issues faced at the park:

- **Shoreline Change:** River shoreline erosion along the shorelines of COLO is significant. It is caused by normal and storm induced wave activity and visitor recreational use. Recent research has provided a better understanding of the shoreline erosion process, those areas experiencing the highest erosion rates and recommendations for conserving the shoreline and its associated cultural and natural resources.

- **Estuarine water quality-**Loss of submerged aquatic vegetation (SAV's) within estuarine habitats at COLO has been noted. Current estuarine water quality within this area is unknown.

- **Aquatic impacts from adjacent land use:** COLO is located adjacent to a rapidly developing urban/suburban area. The entire park has a direct hydrological link to the Chesapeake Bay. Numerous streams, creeks and ponds with major portions of their drainage basin upstream and outside of park boundaries, flow through the park and feed directly into the York or James River. Preliminary analysis of physical attributes and benthos in some of these streams indicate that they are impaired. Activities from adjacent urban and agricultural development may have a detrimental effect on water quality within the park.

- **Groundwater contamination:** Testing indicates potential local sources of groundwater contamination from nitrate and ammonia at several sites near Jamestown Island, Williamsburg and Yorktown. The US Geological Survey, USGS is conducting a study to develop the hydrogeological framework of the Yorktown area of the park and surrounding environs.

- **Visitor and recreational use impacts/Endangered species protection-**COLO has the second highest number of rare, threatened and endangered species of all the National Park Service units in the state. Visitor impacts and recreational activity effects on rare, threatened and endangered species and other species is unknown

- **Exotic species management**-Currently the impacts of exotic species on native species and rare/sensitive habitats is unknown.

Figure 3. Colonial National Historical Park Visitor Map

Fire Island National Seashore (FIIS)

Fire Island is a barrier island located along the southern coast of Long Island, New York. Approximately 51 km long and averaging about 0.5 km in width, the island is bordered by the inlets of Fire Island to the west and Moriches to the east and is separated from Long Island by the Great South and Moriches Bays. Under Public Law 88-587, Fire Island National Seashore (FIIS) was established on September 11, 1964, "for the purpose of conserving and preserving for the use of future generations relatively unspoiled and undeveloped beaches, dunes and other natural features…" (NPS 1999). The Fire Island National Seashore consists of 42 km of Fire Island itself (Figure 4). The Seashore is 7,832 hectares, not including Smith Point County Park located at the eastern end within the boundaries of the National Seashore. Approximately 4,300 hectares of the Park are submerged in the Great South Bay or Atlantic Ocean. The Smith Point County Park (from Smith Point West to Moriches Inlet) falls within the boundary of the National Seashore but is administered by the Suffolk County Park Commission. Robert Moses State Park, on the western end of Fire Island, is not within the authorized boundary of FIIS and is managed by the Long Island State Park Regional authorities.

Natural resource management at FIIS deals with extremes in land use issues within the park. The only federally designated wilderness in the state of New York and in National Parks of the Northeastern United States is found on eastern Fire Island, between Smith Point and Watch Hill. On the hand, seventeen private resort communities comprising approximately 4,000 homes, lie within the administrative boundary of FIIS on the western end of the island. The presence of these communities complicates management in the park. These communities are accessed either by boat across the Great South Bay or by vehicle via the Robert Moses Causeway. Annual visitation to the National Seashore exceeds 1 million.

The physiognomy of Fire Island is typical of Atlantic barrier islands that grade from a primary dune along the ocean to salt marsh along the bay. The dominant vegetation includes pitch pine (*Pinus rigida*), beach grass (*Ammophilia breviligulata*), wax myrtle (*Myrica cerifera)*, bayberry (*M. pensylvanica*), shadbush (*Amelanchier canadensis*), and common greenbrier (*Smilax rotundifolia*). This particular composition of vegetation is typical of the island except within the various communities where residents have planted non-indigenous vegetation.

The percentages of terrestrial habitats found at FIIS include: 10% forested and 40% wetlands, 25% open (beach, swale and fields), 25% developed either by NPS or the 17 local communities on the island. Of the submerged portion, 80% is in Great South Bay and 20% is the Atlantic Ocean. All existing habitats within FIIS are listed as threatened. Unique Resources include the Sunken Forest that is a maritime Holly Forest; a Federal Wilderness Area (520 hectares); and eel grass beds. The Sunken Forest on Fire Island is a 16 hectare maritime oak-holly forest occurring behind the secondary dune, one of only a few mature maritime forests in the New York area and the northernmost holly-dominated maritime forest on the Atlantic barrier island chain. The Nature Conservancy lists this community type as globally imperiled (G2). Both Federal and NYS Endangered species either breed or germinate in the park, as well as eleven species of concern..

The William Floyd Estate (FIIS-WFE), located across Great South Bay on Long Island mainland, is quite different from FIIS's barrier island habitat. The William Floyd Estate is 65% forested, 25% wetlands including salt marsh, 5% open space and 5% developed around the estate house area. Species found at FIIS-WFE include great blue herons, great and snowy egrets, willets, and diamond-backed terrapins.

Some of FIIS' natural resource management issues include:

- **Threatened/Endangered Species and Rare Species Management**- There is a need for more extensive research and species zone delineation to protect R, T and E animals and plants and a need

for direct habitat restoration activities. Issues include prevention of recreational stress on vegetation species, many species of which are threatened or endangered and monitoring disturbance of endangered and threatened vegetation.

- **Wildlife and habitat health**- Re-inventorying FIIS fauna to update and identify distribution and impact type issues is needed. Other issues include managing deer overpopulation due to recreational feeding of deer; preventing the spread of lyme disease to visitors; preventing over browsing of vegetation by deer; maintaining good water quality for finfish and shellfish nursery habitat. Also, recreational and commercial fishing survey is needed to determine impacts on the finfish population.

- **Aquatic Resources**-The chemical and biological condition of FIIS salt water estuaries is unknown. State Fisheries data indicate finfish and shellfish populations are stressed due to pollution and degradation of habitat near FIIS. Identifying impacts to aquatic resources possibly due to channel and marina dredging and pollution from community marinas is needed.

- **Air Resources**-There is a general lack of knowledge regarding air quality on FIIS; Monitoring is needed.

- **Recreation and Visitor Use impacts**-Issues include preventing primary dune vegetation loss due to pedestrian and vehicle disturbance; controlling the extent of human disturbance on plant species in sensitive areas such as The Wilderness Area and the Sunken Forest and controlling the use of personal watercraft due to aesthetic impacts.

- **Impacts to Aesthetic Resources**-Aesthetic concerns include structures, bulkheads, groins, beach scraping and barrier island uses

- **Lateral sand transport**-Bottom dredging of the marina channels disrupts bayside lateral sand transport. The groins on the Ocean Beach impact lateral sand transport on the ocean side. Extensive study of sand transport on FIIS is needed.

- **Mosquito management**-The extent of public threat due to Eastern Equine Encephalitis at areas on FIIS is being investigated and the is a need to determine the applicability of Open water Marsh Management to decrease mosquito populations.

- **Adjacent landuse**-Determining impacts of water quality due to heavily populated region

- **Exotic species management**-The dominance of exotic species on Fire Island is not being studied sufficiently. Preliminary studies suggest exotics plant in the private communities on FIIS may be encroaching onto federal lands (i.e. bamboo). Also phragmites continues to increase in the marsh areas if the Wilderness.

- **Shoreline change**-There is a need to continue to monitor shoreline change to determine the extent of change seasonally and after unusually strong storms

- **Saltmarsh restoration**-Monitoring and research is required to determine the if passive restoration is the best action at this time.

Figure 4. Fire Island National Seashore Visitor Map

Gateway National Recreation Area (GATE)

Gateway is 10,644 hectares of coastal uplands, freshwater ponds, marshes, bays and mudflats. Established in 1972, it is divided into three geographically separate units that constitute some of the largest and most significant natural areas remaining in the metropolitan New York City area (Figure 5). They include the Jamaica Bay/Breezy Point Unit (Riis Park, Fort Tilden, Breezy Point Tip, Floyd Bennett Field, Plumb Beach, North shore of Jamaica Bay and the 3,662 hectare Jamaica Bay Wildlife Refuge); the Staten Island Unit (Great Kills Park and Miller Field) and the Sandy Hook Unit.

Jamaica Bay/Breezy Point Unit-The Jamaica Bay habitat complex is located on the southwestern tip of Long Island in the boroughs of Brooklyn and Queens, New York City and the town of Hempstead, Nassau County. The bay connects with Lower New York Bay to the west through Rockaway Inlet and is the westernmost of the coastal lagoons on the south shore of Long Island. Breezy Point is the western tip of the Rockaway barrier beach to the south of Jamaica Bay and Rockaway Inlet. This habitat complex includes the entire Jamaica Bay estuarine lagoon, part of Rockaway Inlet, and the western part of the Rockaway barrier beach. The boundary of this area generally follows the shoreline of Jamaica Bay and includes most of the tidal creeks and undeveloped upland areas adjacent to the bay; these serve as buffers for the bay, as upland habitat, and as existing and potential restoration sites. This complex also contains the western end of the Rockaway barrier beach and the Marine Park/Plumb Beach area just to the west of the main body of Jamaica Bay to include beach and dune habitat for nesting bird and rare plant species. The bay proper and portions of Rockaway Inlet encompass important breeding and juvenile nursery habitat for fisheries as well as year-round foraging areas for waterfowl, shorebirds, and colonial nesting waterbirds. The extensive salt marsh and upland islands in the bay provide nesting habitat for gulls, terns, waterfowl, and herons; foraging and roosting habitat for shorebirds and waterbirds; upland sites for grassland bird nesting and foraging areas; and butterfly concentration areas. Despite the surrounding intensive residential, commercial, and industrial development, Jamaica Bay and Breezy Point continue to be incredibly valuable for resident and migratory fish and birds and for other wildlife and plant populations.

Jamaica Bay has been designated and mapped as an otherwise protected beach unit pursuant to the federal Coastal Barrier Resources Act, prohibiting incompatible federal financial assistance or flood insurance within the unit. The New York State Natural Heritage Program, in conjunction with The Nature Conservancy, recognizes Breezy Point as a Priority Site for Biodiversity (B2 - very high biodiversity significance). Jamaica Bay and Breezy Point have been designated as Significant Coastal Fish and Wildlife Habitats by the New York State Department of State, and the bay up to the high tide line was designated as a Critical Environmental Area by the New York State Department of Environmental Conservation. Jamaica Bay was also designated as one of three special natural waterfront areas by New York City's Department of City Planning.

Jamaica Bay is a saline to brackish, eutrophic (nutrient-rich) estuary covering about 10,118 hectares (25,000 acres), with a mean depth of 4 meters (13 feet), a semidiurnal tidal range averaging 1.5 meters (5 feet), and a residence time of about 33 days. The bay communicates with Lower New York Bay and the Atlantic Ocean via Rockaway Inlet, a high current area that is one kilometer (0.63 mile) wide at its narrowest point, with an average depth of 7 meters (23 feet). Measurements taken during recent surveys in Jamaica Bay indicate average yearly ranges for temperature of 1 to 26°C (34 to 79°F), salinity of 20.5 to 26 parts per thousand, dissolved oxygen of 3.5 to 18.5 milligrams/liter, and pH of 6.8 to 9. Loadings of nutrients and organic matter into the bay from sewage treatment plants and runoff result in phytoplankton blooms and high suspended solid concentrations which, in turn, result in turbid water and low bottom dissolved oxygen concentrations. Jamaica Bay is in the middle of the New York City metropolitan area and the uplands around the bay, as well as much of the Rockaway barrier beach, are dominated by urban, residential, commercial, and industrial development. The bay itself has been

disturbed by dredging, filling, and development, including the construction of Floyd Bennett Field and John F. Kennedy Airport. About 4,856 of the original 6,475 hectares (12,000 of the original 16,000 acres) of wetlands in the bay have been filled in, mostly around the perimeter of the bay. Extensive areas of the bay have been dredged for navigation channels and to provide fill for the airports and other construction projects.

The center of the bay is dominated by subtidal open water and extensive low-lying islands with areas of salt marsh, intertidal flats, and uplands important for colonial nesting waterbirds. The average mean low tide exposes 142 hectares (350 acres) of mudflat, 375 hectares (925 acres) of low salt marsh dominated by low marsh cordgrass *(Spartina alterniflora*), and 213 hectares (526 acres) of high marsh dominated by high marsh cordgrass *(Spartina patens*). The extensive intertidal areas are rich in food resources, including a variety of benthic invertebrates and macroalgae dominated by sea lettuce (*Ulva latuca*). These rich food resources attract a variety of fish, shorebirds, and waterfowl. This area is largely separated from disturbance and predation occurring on the surrounding mainland, and support large numbers of nesting waterbirds and diverse migratory birds throughout the year. At least 326 species of birds have been sighted in the Refuge, including confirmed breeding by 62 species.

Breezy Point contains an approximately 81-hectare natural area at the western tip of the Rockaway Peninsula with an accreting wide ocean beach, beachgrass dunes, grassland/shrub thicket, and fringing salt marshes on the bay side. A stone jetty extends out from the tip of Breezy Point. East of this natural area, the barrier behind the beach front has been largely developed into residential, commercial, and recreational areas.

Floyd Bennett Field is a 579 hectare historic civic aviation facility dominated by human-made structures and runways but with extensive areas of open space between the runways. It includes a 57 hectare grassland area restored and maintained by the National Park Service and New York City Audubon Society as the Grassland Restoration and Management Project. There are smaller areas of shrub thicket dominated by bayberry, winged sumac (*Rhus copallina*), and Japanese knotweed (*Polygonum cuspidatum*) as well as developing woodland consisting of black cherry, grey birch (*Betula populifolia*), and cottonwood (*Populus deltoides*). Common reed (*Phragmites australis*) marsh and small areas of low marsh and mudflat along the shoreline of the bay exist as well.

The location of Jamaica Bay and Breezy Point and the rich food resources found there make it a regionally important fish, wildlife, and plant habitat complex. Jamaica Bay is located adjacent to the confluence of the New York Bight and New York Bay, and is at the turning point of the primarily east-west oriented coastline of New England and Long Island and the north-south oriented coastline of the mid-Atlantic coast. This geographic location acts to concentrate marine and estuarine species migrating between the New York Bight portion of the North Atlantic and the Hudson-Raritan Estuary. Shorebirds, raptors, waterfowl, landbirds, and various migratory insects are concentrated by the coastlines in both directions. These migratory species are further concentrated by the surrounding urban developed land into the remaining open space and open water of Jamaica Bay. Jamaica Bay and Breezy Point support seasonal or year-round populations of 214 species of special emphasis and listed species, incorporating 48 species of fish and 120 species of birds, and including the following federally listed and state-listed species.

Staten Island Unit -The Great Kills Harbor and Park include large areas of disturbed common reed marsh with grassland and shrub thicket at Crookes Point. The outer shoreline follows a narrow, sandy, groined beach. A large area of flats in Great Kills Harbor extends southwest along the Staten Island Shoreline as far as Wolfe's Pond**.**

The significance of this complex relates to its geographic location and to the variety and quality of habitat types found here; these include shallow estuarine open waters, sandy beach, maritime forest, salt marsh, mudflats, and riparian forest. These habitats support a large number of regionally rare and important species. Due to its complex geology and glacial history, Staten Island supports an unusual diversity of habitat types and rare plant species.

Sandy Hook Unit- Sandy Hook is the only undeveloped barrier beach area on the northern end of the New Jersey coastline north of Island Beach State Park, located 55 kilometers (34 miles) to the south. Its sandy shorelines and backdunes provide germination and breeding habitats for a variety of threatened, endangered and rare species of flora and fauna. Maritime holly forests that occur at Sandy Hook occur at only a few other locations in the region and are a globally imperiled community due to their rarity. The forests are important as roosting and nesting locations for a variety of birds, and include historical nesting by great blue heron, historical nesting and present roosting by black-crowned night-heron (*Nycticorax nycticorax*), and nesting by several pairs of osprey and several species of passerines. The holly is also a host plant for the regionally rare butterfly Henry's Elfin (*Incisalia henrici*)

Raritan and Sandy Hook Bays form the southeastern portion of the New York - New Jersey Harbor between the southern shoreline of Staten Island, Richmond County, New York, and the northern shoreline of Monmouth County, New Jersey. Raritan Bay - Sandy Hook Bay is a large embayment measuring nine by twelve miles (109 square miles) with a surface area of about 28,000 hectares (69,188 acres). The inshore portion of the bays within this habitat complex has a total area of 13,500 hectares (33,500 acres). The wetlands, uplands, and nearshore waters form a bayshore complex which is critical for migratory and resident birds and fish. Raritan and Sandy Hook Bays are divided between the states of New Jersey and New York, and receive direct inflow from the Raritan River, the Shrewsbury and Navesink Rivers, and numerous smaller tributaries along the shorelines of Staten Island and New Jersey. The bay is relatively shallow, usually less than 6 meters (20 feet) in depth except for dredged channels which range in width from 24 to 427 meters (80 to 1400 feet) and are 3 to 11 meters (10 to 35 feet) in depth. The tidal range averages 1.7 meters (5.5 feet). Compared with other parts of the New York - New Jersey Harbor Estuary, the shorelines of Raritan and Sandy Hook Bays have more remaining natural shoreline and open space. The area is subject to a wide variety of fluctuations in temperature, salinity, and dissolved oxygen, both from natural and anthropogenic activity, especially industrial and sewage effluent and storm-water runoff.

The Sandy Hook Peninsula separates the Atlantic Ocean from the southern portion of the New York - New Jersey Harbor Estuary and serves as a dividing line between certain groups of species, with marine, estuarine, and anadromous species concentrated on the outside, shorebirds and waterfowl concentrated on the inside, and migratory landbirds (raptors and passerines) concentrated on the peninsula itself. As is true with Jamaica Bay and Breezy Point on the other side of the Harbor entrance, Sandy Hook and Sandy Hook Bay are at the turning point of the primarily east-west oriented coastline of New England and Long Island and the north-south oriented coastline of the mid-Atlantic coast. This geographic location and configuration acts to concentrate marine and estuarine species migrating between the New York Bight portion of the North Atlantic and the Hudson-Raritan Estuary. Also, shorebirds, raptors, waterfowl, landbirds, and a variety of migratory insects migrating in both directions are concentrated in the Harbor by these coastlines. These migratory species are further forced by the surrounding urban developed land into the remaining open space and open water of Raritan and Sandy Hook bays and surrounding coastlands. There are 205 species of special emphasis regularly using the waters and shorelands of Raritan Bay and Sandy Hook.

Gateway National Recreation Area natural resource management issues include:

- **Urban/Development Associated Impacts**: Jamaica Bay is in the middle of the New York City metropolitan area and the uplands around the bay, as well as much of the Rockaway barrier beach, are dominated by urban, residential, commercial, and industrial development. Consequently, issues such as habitat fragmentation, increases in road kills, increased pet predation on native wildlife and increased levels of human activity/disturbance within the park must be considered.

- **Adjacent land uses that impact on aquatic systems**- Loadings of nutrients and organic matter into Jamaica Bay from sewage treatment plants and runoff result in phytoplankton blooms and high suspended solid concentrations which, in turn, result in turbid water and low bottom dissolved oxygen concentrations. At Sandy Hook, the surrounding waters are subject to a wide variety of fluctuations in temperature, salinity, and dissolved oxygen, both from natural and anthropogenic activity, especially industrial and sewage effluent and storm-water runoff.

- **Loss of Marsh habitat/islands in Jamaica Bay**-The bay has been disturbed by dredging, filling, and development, including the construction of Floyd Bennett Field and John F. Kennedy Airport. About 4,856 of the original 6,475 hectares (12,000 of the original 16,000 acres) of wetlands in the bay have been filled in, mostly around the perimeter of the bay. Extensive areas of the bay have been dredged for navigation channels and to provide fill for the airports and other construction projects. Current scientific research shows Jamaica Bay losing a significant amount of marsh habitats and islands annually. Jamaica Bay and its associated marsh habitats are noted as critical for several species of breeding birds and fish as well as for growth and development of birds, fish, diamondback terrapins and some sea turtles.

- **Wildlife Management Issues include:** Aircraft collision with birds originating in GATE; Neotropical migrants use of park habitats; Other wildlife species that have the potential to impact on piping plover (federally listed species) and other beach nesting birds such as roseate tern, American oystercatcher and black skimmer (all state listed species); potential rabies vectors such as raccoons;

Figure 5. Gateway National Recreation Area Visitor Map

George Washington Birthplace National Monument (GEWA)

George Washington Birthplace National Monument is located on the northern neck of rural and tidal Virginia about 56 kilometers east of Fredericksburg on highway 3 and about 97 km south of Washington, D.C. in Westmoreland Co. (Figure 6). The park consists of 220 hectares along the tidal reaches of the Potomac River. The park is fairly flat, typical of the coastal plain. Bounded by the Potomac on the north, the western edge of the park includes Bridges Creek, marsh and private lands, with the southern portion bounded by Pope's Creek estuary and private land, Pope's Creek is found to the east. GEWA lies within the Potomac River watershed, and the greater Chesapeake Bay watershed. Three small sub-basins drain into the Potomac at GEWA. These are Pope's Creek, Bridges Creek, and a third unnamed creek. Land-use in these three sub-basins is largely agricultural. Salinity of Pope's Creek and other marshes within the park can be as much as 60% sea water with crabs, jellyfish, oysters and other marine organisms present. Erosion along the Potomac shoreline is severe and represents significant threats to the park. Primary habitats include about 100 ha of mixed conifer/hardwood forest and loblolly plantations, 90 ha of open fields, 60 ha of fresh and saltwater marshes and swamps, and 7 ha of developed and historic areas. Three freshwater ponds and about 2000 meters of Potomac beach and cliffs are also present.

George Washington Birthplace National Monument natural resource management issues include:

- **Shoreline Change:** Erosion along the Potomac shoreline is severe and represents significant threats to estuarine water quality, salt marsh health and biotic diversity. Documentation of the impacts from erosion at GEWA including loss of plant species is needed to provide a better understanding of the shoreline erosion process, those areas within GEWA experiencing the highest erosion rates and recommendations for conserving the shoreline and its associated cultural and natural resources.

- **Water quality**-Extensive testing or documentation of freshwater and estuarine water quality is required to determine potential contaminant impacts to aquatic habitat health at GEWA. This work is essential in order to begin the process of possibly restoring Pope's Creek as a spawning area for species such as oysters and sturgeon

- **Wildlife Management**- Issues include protection of rare, threatened and endangered wildlife species; appropriate deer and woodchuck population management

- **Habitat management**- Issues include documentation of habitat health within forested and marsh areas; native warm-season and meadow grass species re-introduction; protection of rare, threatened and endangered vegetative species

- **Exotic species management**-Currently the impacts of exotic species on native species and rare/sensitive habitats is unknown.

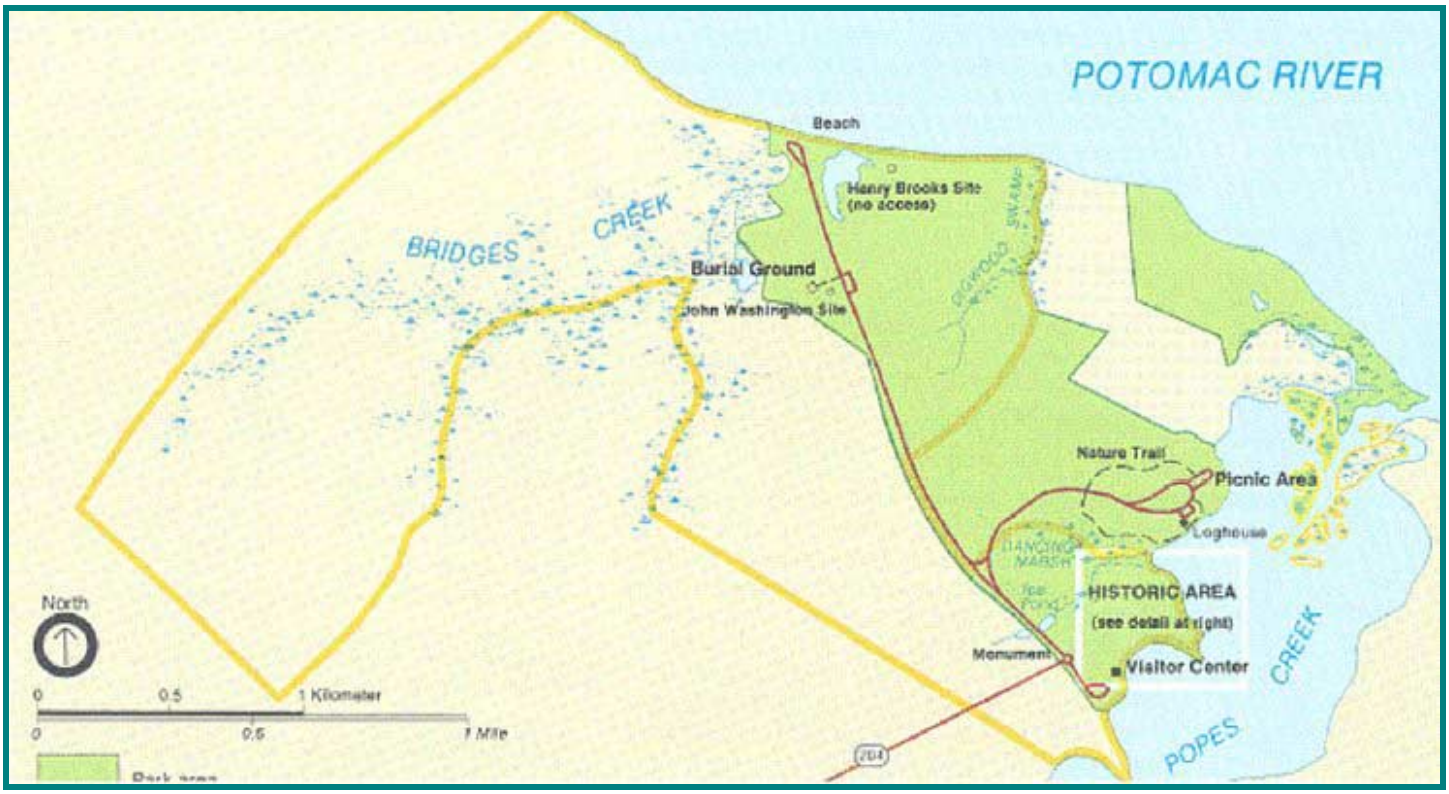

Figure 6. George Washington Birthplace National Monument Visitor Map

Thomas Stone National Historic Site (THST)

Thomas Stone National Historic Site is located about 32 km south of Washington D.C (no map digital map available). The site is comprised of 130 hectares of hilly lands that drain into the Hoghole Run, emptying into the Port Tobacco Creek about 1.75km south of the park boundary. Relief of the landscape is approximately 35 meters with three main drainages and numerous springs and seeps. About 100 ha are mixed forests, 20 ha fields, and 2 ha of developed area.

No biological inventories have been done at THST so there has been a large gap in knowledge about the existing natural resources found there. Over the past couple of years due to the Natural Resource Challenge, implementation of vertebrate and vascular plant inventories has begun in the park. In 2001, a vegetation classification and mapping project was initiated at THST, The principal investigator for the vegetation classification portion of this project, found and collected a sedge species of the genus *Carex* that did not match known species for the state, even following comparisons with specimens in herbaria. The specimen was forwarded to Dr. Tony Reznicek (University of Michigan and a Flora of North America (FNA) author for the genus), who recognized it as a species that was undescribed but the subject of a taxonomic paper in progress by two colleagues. Dr. Reznicek delivered the specimen to one of the authors, Dr. Rob Naczi (Delaware State University and another FNA author), who confirmed its identity. Dr. Naczi and his co-author, Dr. Charles Bryson, plan to cite the Thomas Stone NHS specimen as a paratype in their paper, which is expected to be published in early 2002 and will formally describe and name this species. (Paratypes are specimens examined by a species author that are supplemental to the holotype ("type specimen") and are often listed in a formal description as representations of a new species across its range and its habitat breadth). Thus, the sedge found at Thomas Stone NHS will contribute to the description of a species new to science and also represent the first known Maryland occurrence of it.

Small parks like THST with cultural themes are often easily dismissed as unlikely reservoirs of biodiversity, let alone sites of new taxonomic discoveries. As inventories on birds, mammals and herps progress in the park, along with the better understanding of the existing biodiversity, natural resource management issues at THST will most likely be evolving as more information becomes available.

Thomas Stone National Historic Site natural resource management issues include:

- **Wildlife Management-** Issues include a need for documentation of wildlife species composition, distribution and abundance and habitat use; need for documentation of rare, threatened, endangered and exotic wildlife species; determining effects of hunting and power line rights of way on species; deer browse monitoring

- **Habitat management-** Issues include a need for documentation of park vegetation species composition, distribution and abundance; a need for documentation of rare, threatened, endangered, exotic and invasive vegetative species; a need for documentation of habitat health within forested and riparian areas; determining effects of power line rights of way on species; native warm-season and meadow grass species re-introduction.

Sagamore Hill National Historic Site (SAHI)

Sagamore Hill National Historic Site is the home of Theodore Roosevelt located on the peninsula of Cove Neck, Long Island, New York (Figure 7). In 1883 Roosevelt purchased farmland with shoreline on both Oyster Bay and Cold Spring Harbor. He quickly sold off some of the property facing Oyster Bay to relatives, and built a large country home on the top of a hill with views across the water. Farm fields gave way to an oak-chestnut-tulip forest running down to a salt marsh that opens to Cold Spring Harbor. His family eventually sold off more acreage until it reached its current size of 35 hectares.

Today the farm has given way to visitor facilities including a parking lot and visitor center (0.8 hectares combined), paved driveways, and mowed lawns (4 hectares). There remains about 4.8 hectares of rough fields. The forest of about 20 hectares has matured despite the loss of the chestnuts to the blight. The easternmost forested and saltmarsh area of the park were declared a "Natural Environmental Study Area" by Congress in the early 1970's. The 4 hectare Eel Creek saltmarsh is an excellent example of the tidal saltmarshes that once lined the shore of Long Island.

Sagamore Hill National Historic Site natural resource management issues include:

- **Wildlife Management-** Issues include a need for documentation of wildlife species composition, distribution and abundance and habitat use; need for documentation of rare, threatened, endangered and exotic wildlife species.

- **Habitat management-** Issues include a need for management recommendations regarding park habitats based on previous documentation and current field work

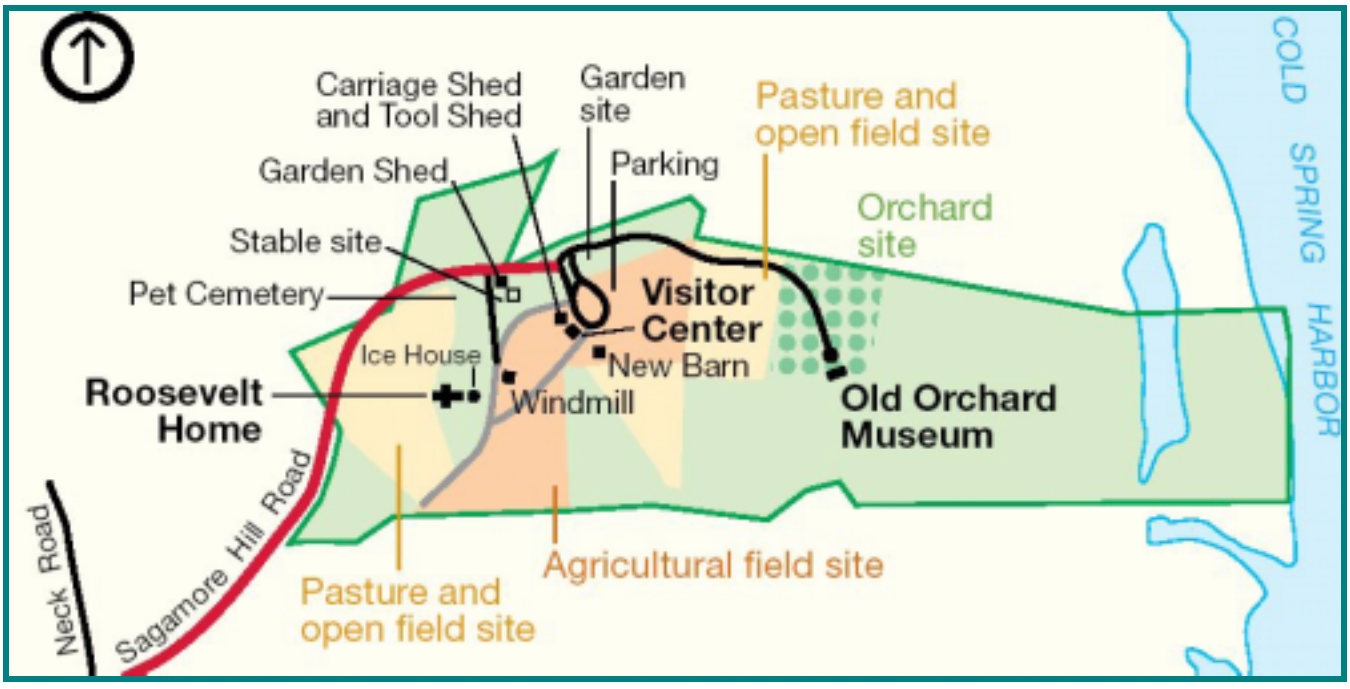

Figure 7. Sagamore Hill National Historic Site Visitor Map

DEVELOPMENT OF THE NORTHEAST COASTAL AND BARRIER NETWORK MONITORING PROGRAM

Establishing Network Committees

In the fall of 1999, through the year 2000 the first three steps of the seven-step plan; forming a steering committee and board of directors, summarizing existing data and understanding, and preparing for and holding a Network Vital Signs Scoping Workshop, recommended by the National Monitoring Program (http://www.nature.nps.gov/im/monitor/approach.htm), were addressed by the Network.

The Coastal and Barrier Network Steering Committee was organized and established to advise and assist in decision making on issues regarding the development and implementation of a coastal park monitoring strategy, hiring of permanent and temporary staff, budgeting, scheduling, and promoting accountability for the program. Members of the steering committee were nominated by park staff, the regional I&M coordinator and regional chief scientists (Table 2). Those selected include scientists familiar with Northeast coastal parks issues or those who have been involved with or implemented research pertaining to coastal ecosystem monitoring.

Table 2. Members of the Northeast Coastal and Barrier Network Technical Steering Committee (2002).

Committee Member	Affiliation/Location
Dr. P. A. Buckley	USGS-University of Rhode Island
Dr. Howard Ginsberg	USGS-University of Rhode Island
Dr. Hilary Neckles	USGS-Augusta, ME
Dr. Charles Roman	USGS-University of Rhode Island
Dr. Allan O'Connell	USGS-University of Maine
Elizabeth Johnson	NPS-University of Rhode Island
Carl Zimmerman	NPS-ASIS
John Karish	NPS-Penn State University
Dr. Mary Foley	NPS-Boston Support Office
Charles Rafkind	NPS-COLO
Dr. Nancy Finley	NPS-CACO
Dr. Bryan Milstead	NPS-University of Rhode Island
Sara Stevens	NPS-University of Rhode Island

A Network Board of Directors was also formed to help manage and oversee the program. The Board includes the seven superintendents (THST and GEWA share a superintendent) from the coastal parks, two chief scientists from the region, the regional inventory and monitoring coordinator and the network inventory and monitoring coordinator. The board works closely with the Network Data Manager and the Technical Steering Committee to insure monitoring goals are met. There is at least one board meeting a year. Their major responsibilities are to assure accountability and effectiveness for the Network Monitoring Program by reviewing progress, quality control, and spending of Network funds. The Board also assists in developing strategies and procedures for leveraging network funds and personnel to best accomplish inventory and monitoring and other natural resource needs of Network parks. They are consulted on the hiring of Network personnel using funding provided to the Network, including base funds and other sources. They also play an important role in seeking additional financial

support to leverage the Servicewide funds and solicit professional guidance from and partnerships with other governmental agencies, organizations and individuals.

Establishing Network Program Goals and Objectives

Tasked with the development of a network-wide monitoring program the Technical Steering Committee agreed that the program should be structured on, not only the goals and objectives of the Servicewide Program, but those established as part of Cape Code National Seashore's monitoring program, a prototype park. The Committee also agreed that the general aim and goals of the CACO monitoring program could help provide initial structure and basis for the development of the coastal network monitoring program. As a coastal park, the issues faced by CACO are of course issues also faced by the other seven Network parks.

Cape Cod National Seashore the Network Prototype Park

In 1996, CACO was identified as a prototype park for long-term ecological monitoring within the Atlantic and Gulf Coast biogeographic region. Development of the CACO long-term ecological monitoring program has been a collaborative effort primarily between U.S. Geological Survey (USGS) and NPS. Although USGS provided the bulk of the funding for development of a conceptual framework for the CACO program and for protocol development, the park began receiving funding specifically for the long-term monitoring program in 1997. In 1999 the "Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Code National Seashore" was completed (Roman and Barrett, 1999) (http://www.nature.nps.gov/im/monitor/caco.pdf). As a prototype park and in partnership with USGS, CACO was charged with developing and refining long-term monitoring protocols that could be of utility to other Atlantic and Gulf Coast parks, in addition to supporting management of Cape Cod's natural resources. With the advent of the network approach to inventory and monitoring, the park's mission has expanded to include focused technical support to the Northeast and Coastal Barrier Network. The overall goals of the CACO Long-term Coastal Ecosystem Monitoring Program (LTEM) are:

- to detect changes in particular attributes of the coastal ecosystem and determine if those changes are within the bounds of natural or historic variability;
- to predict how those changes relate to natural processes and human-influences; and,
- to understand how such changes, ultimately, affect the condition of the coastal ecosystem.

The information generated from the CACO program is intended to assist park managers in clarifying and addressing issues as part of their decision-making process. A long-term ecosystem monitoring program should help to answer questions such as: Do the observed changes represent current problems or forecast emerging problems that might adversely affect the ecological integrity of the coastal ecosystem? Do the problems require immediate action? Can the problems be remedied by management actions? Understanding the dynamic nature of coastal ecosystems and the consequences of human activity is essential for management decision-making aimed to maintain, enhance, or restore the ecological integrity of the coastal ecosystem and to avoid, minimize, or mitigate ecological threats to the coastal ecosystem. Specifically, the success of the Coastal and Barrier Network and the Cape Cod National Seashore's long-term monitoring programs are dependent upon the ability to answer these questions within a scientific framework.

Identification of Important Network Management and Scientific Issues

Development of a long-term monitoring program for the Northeast coastal parks has been evolving over a number of years. Workshops and symposia have been held in recent years by USGS and NPS scientists to discuss the need for ecological monitoring programs in these coastal parks. In September

1997, the NPS Northeast Region held a two day inventory and monitoring workshop at the Patuxent Wildlife Refuge Visitor Center in Laurel, Maryland. Ten parks were involved, including four of the Coastal and Barrier Network parks. The title of the workshop was *Developing a Conceptual Design for a Multi-park, Long-term Monitoring Program in the Northeast Field Area, National Park Service.* The purpose of this workshop was to develop a Northeast field area-wide monitoring strategy.

The four Coastal and Barrier Network parks that took part in this workshop were, CACO, FIIS, GATE and ASIS. Below is a list of management issues (not in any prioritized order) identified during the workshop for each of these four parks. Although each park identified other management issues, the following list of issues were common among all four parks.

- **Adjacent land development**
- **Accelerated estuarine nutrient enrichment**
- **Increasing visitor use and recreational impacts**
- **Shoreline change**
- **Rare species-protection**
- **Water quality**
- **Exotic species impacts**

In 1999 a two day symposium was held at Patuxent Wildlife Research Center on coastal issues and information needs. Internationally recognized leaders in coastal ecology joined forces with DOI coastal land and resource managers to identify key scientific issues, information gaps, and long-term data needs that are relevant within a coastal resource management framework. Again, like at the 1997 Northeast Region Inventory and Monitoring workshop, the management issues identified during this meeting were similar across the coastal parks and included adjacent land development, estuarine water quality and nutrient enrichment, increasing visitor and recreational use and their impacts, shoreline erosion and exotic species.

Finally in, February 2000, as part of the Patuxent Wildlife Research Center's annual science meeting, a workshop was held titled *Developing a Scientific Basis for Integrated Long-Term Monitoring of Atlantic Coastal Parks and Refuges*. The workshop objectives included identifying indicators for long-term monitoring that provide quantitative information on coastal ecosystem functions and identifying threshold values for coastal ecosystem indicators that denote sustainable vs. degraded systems.

Unfortunately, the lack of funding prior to the NPS Natural Resource Challenge limited further development of the plans and ideas discussed at the time of these meetings. Once full funding became available for Networks to develop and implement their programs, the Northeast Coastal and Barrier had a great deal of material already compiled to help plan the first Network Vital Signs scoping workshop. Important management and scientific issues for each park had been identified and well defined because of these initial workshops and it was clear that a number of common issues had been repeatedly discussed and prioritized for monitoring in these parks. Issues such as shoreline change, estuarine nutrient enrichment, and visitor impacts were persistent themes at all previous coastal monitoring symposia and workshops.

Holding the first Network Scoping Workshop

As part of the first meeting of the Network Steering Committee, the Committee developed and planned a Network Vital Signs Scoping Workshop. This first "Network" scoping workshop was to be used as an initial "data mining" workshop. Many people were invited including local scientists from other agencies and universities with expertise in coastal issues as well as WASO I&M staff, and park and network staff. The goal of the workshop was to discuss the key management issues that were identified

by the Technical Steering Committee and to develop a candidate list of "vital signs" or environmental indicators for each management issue. The hope was to develop a list of indicators that could be further tested for possible inclusion in a long term monitoring program for the Network.

The Technical Steering Committee put together a list of people who should attend, an agenda, organized breakout groups, group questionnaires and guidelines. Like the CACO "prototype" monitoring program, the Committee chose four ecosystem types to base discussions on, relevant to all the Network parks.

1. **Estuaries and near shore environment**
2. **Freshwater wetlands, pond and streams**
3. **Uplands (forests, grasslands and thickets)**
4. **Beaches, dunes, spits and shoreline systems**

For each of these ecosystem types detailed conceptual models had already been developed as part of the framework for CACO's monitoring program and were made available at the workshop. These models include: agents of change, stressors and ecosystem responses. Breakout groups were organized by the Steering Committee based on five high priority management issues common to all of the Coastal and Barrier Network parks..

1. **Shoreline Change**
2. **Water Quality**
3. **Species and Habitats of Concern**
4. **Resource Extraction**
5. **Recreation and Visitor Use**

The steering committee proposed some monitoring questions and provided some candidate indicators or "Vital Signs" for each of these management issues based upon the CACO program to help each workgroup initiate their discussion.

Workshop Preparation

Prior to the scoping workshop, participants were sent a briefing package that included material to 1) familiarize them with the Network parks and their specific management issues, 2) explain the purpose of the NPS I&M Program and the scoping workshop and 3) provide a conceptual background for planning a monitoring strategy. The complete package of briefing materials included:

- A list of species and habitats of concern for each Network park.
- A list of species/resources extracted from the park by hunting, fishing, poaching, groundwater removal, sand, crops, etc…and the habitats impacted by removal.
- A list of fully operational, ongoing monitoring programs existing in each park.
- A list of additional management issues not included in the list created by the steering committee.
- Vital Signs Workshop Agenda and description of workshop format, as well as product examples to be created during the workshop.
- A list of management issues in coastal and barrier parks.
- A summary of a workshop held by the Patuxent Wildlife Research Center on coastal issues
- Description of Coastal and Barrier Network Parks resources and settings, including responses to questions listed above.
- Conceptual framework for the development of long-term monitoring protocols at Cape Cod National Seashore.
- GIS layers available for each park.

The Scoping Workshop

On April 13 and 14, 2000, the first Network Vital Signs Scoping Workshop was held at Gateway National Recreation Area. Forty-one people attended. Participants divided up into the five breakout

workgroups based on the management issues identified by the steering committee; shoreline change, water quality, species and habitats of concern, resource extraction and recreation and visitor use. Each workgroup was directed by a leader, who guided the participants through discussion and completion of the vital signs questionnaire for each indicator addressed, and the completion of a workgroup summary sheet Following the scoping workshop, the workgroups were asked to submit a report detailing their discussions. The following is a summary of those reports.

Scoping Workshop Workgroup -Water Quality

The water quality workgroup created a list of what they considered the most significant water quality management issues for the Coastal and Barrier Network. The workgroup reported that at a minimum, a vital signs monitoring program should be capable of detecting change in park ecosystems relative to: Nutrient enrichment (including harmful algal blooms; Contaminants (including toxics, bacterial contamination, marine debris, and sediments); Hydrologic alteration (including tidal restriction, groundwater withdrawal, saltwater intrusion); and Acidification. They then developed the following three broad monitoring questions:

- **Is water quality changing outside the bounds of natural variability?**
- **Does changing water quality impact natural and cultural resources and visitor use?**
- **What are the causes of changes in water quality?**

The group addressed and prioritized vital signs for these monitoring questions as follows, as well as provided measurement parameters that could be considered.

(1) **Basic Water Quality** (Applies to estuaries and near shore environments; freshwater wetlands, ponds, streams) Measurement parameters:
- Temperature
- Salinity (salt water)
- Electrical conductivity (freshwater)
- Dissolved oxygen (to include diel depth profiling as needed to determine the depth and duration of hypoxia/anoxia)
- Total Nitrogen, Phosphorus
- pH
- Acid Neutralizing Capacity
- Depth
- Turbidity/% light transmission
- Total water column chlorophyll a
- Total suspended solids
- Fecal-Indicator Bacteria

(2) **Land Use/Land Cover/Vegetation Mapping** (Applies to estuaries and nearshore environments; freshwater wetlands, ponds, streams) Measurement parameters:
- Watersheds within and outside park boundaries
- Distribution of major vegetation types (including submerged aquatic vegetation and potentially macroalgae)

(3) Fauna (Applies to estuaries and nearshore environments; freshwater wetlands, ponds, streams) Measurement parameters:
- Species richness
- Distribution and abundance of macroinvertebrates in saltwater environments
- (The value of fish should be reviewed as a potential faunal indicator instead of or in addition to macroinverts)

(4) Surface and groundwater levels (Applies to estuaries and nearshore environments; freshwater wetlands, ponds, streams, uplands and beaches, dunes, spits and shoreline systems) Measurement parameters:

- Distribution and connectedness of surface waters (including seasonal and tidal components of surface water cover and depth)
- Precipitation (quantity)
- Groundwater chemistry (annually)

(5) Water Column-Sediment Toxicity (Applies to estuaries and nearshore environments; freshwater wetlands, ponds, streams, uplands and beaches, dunes, spits and shoreline systems) Measurement parameters:

- Bioassays using macroinvertebrates
- Tissue residues in fish and shellfish
- Sediment chemistry

(6) Amphibian distribution and abundance (freshwater wetlands, ponds and streams) Measurement parameters:

- No specific measurement parameters were indicated by the workgroup

*Scoping Workshop Workgroup-Shoreline Change ("Shore Zone" Change**)***
The shoreline change workgroup collectively agreed that one of the fundamental problems facing resource managers in coastal or barrier parks is the spatial patterns of loss or gain of land due to shoreline change. Coastal parks such as Assateague Island, Fire Island and Gateway need to monitor shoreline changes to better understand and predict the effects of this fundamental attribute. The Chesapeake Bay parks such as COLO and GEWA have similar land loss issues. Shoreline changes, resulting from a combination of natural coastal processes and processes altered by human manipulation of shorelines or sediment supplies, can have profound effects on natural resources, habitats and the built and historic environment, both cultural and archaeological resources and visitor facilities. For example, the process of shoreline change directly affects dune and vegetation patterns, which in turn, determine the availability of critical habitat for threatened species such as the piping plover and seabeach amaranth.

For managers, an understanding of the spatial and temporal patterns of shoreline change is basic to optimal management of any coastal park because: 1) the interface of marine and land systems is very dynamic and is driven by multiple forcing mechanisms, 2) it results in alterations to resource patterns and dynamics at habitat and ecosystem conditions, and 3) it will eventually result in the loss of static cultural resources. Preservation and protection is mandated for resources, which are threatened and considered of national significance, even though this does not require in situ retention.

The Shoreline Change workgroup based their discussion of vital signs on one general monitoring question:

- **What is the spatial and temporal variation of the frequencies and magnitudes of coastal change?**

The group identified three basic elements of change that are reasonably easy to measure and are replicative for time series analysis with adequate accuracy and precision, in order to understand the space/time pattern of shoreline change. The latter, combined with items 1 and 2, provides dimensional data on imbalances in mass budgets at specific spatial scales. In priority order, these variables are:
(1) *an approximation of the oceanic shoreline;*
(2) *a measure of the more inland interface of the upland edge vs. wave domination; and*
(3) *elevational change data characteristic of the coastal topographic envelope of concern.*
The northeastern U.S. coastal park shorelines can be separated simply into two groups: **1)** *open ocean shores* with high wave energy, mobile (usually sand-sized) sediments, and large length scales of

sediment transport (Cape Cod NS is the only exception to extra-boundary sources and sinks characterizing the other barrier island parks), and **2)** *fetch-limited shores* in estuarine locales which are defined by very small space scales for sediment transport. Barrier islands and Cape Cod contain both. Each of these two elements also possesses different morphology and vegetation, which restrict logistically and technologically the choice and accuracy of available methodologies for assessing shoreline change trends.

The following is a list of vital signs the group developed including methods of measurement.

(1) Shoreline position (Temporal variability (mean high water) Spatial variability ("fetch-limited" shorelines))
- Aerial imagery
- GIS oriented data
- 2-D or 3-D Field surveys

(2) Landward limit of shore zone change
- Aerial imagery
- GIS oriented data
- 2-D or 3-D Field surveys

(3) Elevational change data characteristics of the coastal topographic envelope of concern
- Airborne topographic mapping

The workgroup then made recommendations for the design and implementation of a Monitoring Program for Shoreline Change. Their recommendations are as follows:
- The three methods suggested for implementation of a monitoring program are available at all space and time scales deemed necessary and affordable.
- The NPS should be careful not to duplicate efforts to train staff and purchase equipment.
- A coordinator should be hired by the NPS I&M Program to lead the monitoring effort.

Scoping Workshop Workgroup-Recreation and Visitor Use

With annual visitation surpassing twenty million, the North Atlantic coastal parks are meccas for outdoor recreation. This visitation is leading to increased traffic congestion, visitor crowding and conflicts, and degradation of natural resources. Unmanaged visitation can pose a significant threat to both the quality of park resources and visitor experiences. As visitation continues to rise, protecting park resources and visitor experiences will be a significant management challenge. Monitoring can play a vital role by providing information about the types, amounts, and distribution of visitor activities and their impacts to park natural resources.

The recreation and visitor use workgroup based their vital signs discussion on two key monitoring questions:

- **How are the type, amount, and distribution of visitor uses changing over time?**

- **What type and extent of resource degradation is occurring?**

The group identified vital signs and provided measurement parameters to consider for these monitoring questions as follows:

(1) Type, amount and distribution of recreation use
- Management workshop to ID and map visitor use
- Direct observation from selected sample points
- Park use assessment methods (entry point questions/counts, parking lot counts)

- Aerial surveys for selected use types (e.g. boats, ORV's)

(2) Vegetation loss and compositional change

- Aerial photography
- Vegetation sampling along trails and recreation sites

(3) Unintended trail proliferation

(4) Unintended recreation site proliferation

(5) Substrate erosion

(6) Wildlife disturbance time

- Direct observation

(7) Wildlife-Road kills

- Road segment sampling

(8) Wildlife-Attraction behavior

- Observation of visitor WL feeding
- Observation of WL attraction behavior

(9) Water Resources-Water turbidity

- Sampling at recreation sites and paired controls

(10) Water resources-biological contamination

- Sampling at recreation sites and paired controls

Scoping Workshop Workgroup-Species and Habitats of Concern

This workgroup focused specifically on non-native and invasive species, rare, threatened and endangered species, and habitats and communities of special significance. Because species and habitats of concern is such a broad category and involves multiple taxonomic groups this workgroup had a difficult time defining specific vital signs compared to the other workgroups. The following is a list of monitoring questions and associated vital signs they discussed:

- **What are the changing trends of exotic and invasive species?**
- **What factors are contributing to exotic species expansion?**
- **What are the effects of exotic/invasive species on Park resources?**
- **What are the changing trends of rare species?**
- **What are the changes in species composition & diversity in major habitats?**
- **What are the changes in spatial distribution and abundance of major vegetation communities (mapping) i.e., communities of concern?**
- **What are the changing trends in featured species (deer, horses)?**
- **What is the rate of change in adjacent land use?**

The group identified the following vital signs for these monitoring questions:

(1) Distribution of invasive species
(2) Change in abundance of exotic species
(3) Abund. of epiphytic algae in eelgrass beds
(4) Adjacent land use rate of change
(5) Human use patterns/change
(6) Soil disturbance
(7) Trend of Exotics
(8) Featured species (e.g., deer, ponies)
(9) Distribution of other species
(10) Reproduction of other species
(11) Population status
(12) Abundance and distribution of rare species

(13) Community status
(14) Vegetation
(15) Native freshwater fish
(16) Amphibians
(17) Migratory bird
(18) Small mammals
(19) Changes in Park resource composition
(20) Abundance and distribution of community types

Scoping Workshop Workgroup-Resource Extraction
The group members began by listing all potential resource extraction issues/threats that could exist within the identified network parks utilizing the group's knowledge and the profiles submitted by each park. They utilized this list to prepare a "Stressor/Response Table". As they generated the list however, it became apparent that most of the issues in this particular work group would probably be duplicated in other groups.

Resource extraction involves species and activities that are seasonal or transient in the parks. It involves shell fishing, fishing, hunting, poaching, groundwater withdrawal, collecting, harvesting, dredging, etc… Eight resource extraction issues were identified by the workgroup:

1. Finfishing (all parks)
2. Shellfishing (all parks)
3. Groundwater Extraction for Potable Water and Irrigation (CACO)
4. Sand Mining (ASIS)
5. Channel Dredging (GATE)
6. Hunting (most parks)
7. Recreational Collecting-mushrooms, shells, butterflies, herps, etc. (not identified as a major issue in any of the Network parks)
8. Surface Water Extraction (COLO)

The workgroup decided upon and prioritized what they felt were the top three monitoring questions based upon the impacts resource extraction has on park resources. They then identified a vital sign for each of the three monitoring questions.

- **What are the effects of groundwater extraction on water tables (very significant), uplands, estuaries, wetlands and surface water availability?** (Ecosystem this Vital Sign applies include, freshwater Wetlands: ponds, streams, Uplands: forest, grasslands, thickets)
    - Vital Sign: Changes in water table and salinity that differ from natural patterns of variation.
- **How does coastal sand mining effect hydrography (residence time, wave climate, loss of shoals, sediment budget)? What is the frequency and intensity of sand dredging?** (Ecosystem this Vital Sign applies to: Beaches, dunes, spits, shoreline systems)
    - Vital Sign: Bathymetry, shoreline change through GIS
- **What are the effects of commercial and recreational shellfish harvesting on park aquatic habitats?** (Ecosystem this Vital Sign applies to: Estuaries and Near Shore Environments)

- Vital Sign: Some measure of habitat disturbance to bottom habitat and associated communities (set up a control area (refuge) within the park for comparisons)

Further Refinement of the Network Monitoring Plan

In September 2000, the Coastal and Barrier Network Steering Committee met for a second time. During this meeting the Committee reviewed the scoping workshop report, the workgroup reports and results and began to plan the next steps for developing a vital signs monitoring program for the Network. The Committee agreed that the scoping workshop was successful in developing "laundry lists" of vital signs for the Network, but agreed that smaller working groups were needed (no more than five people per group) to begin fine tuning the monitoring questions and lists of indicators developed by the scoping workshop workgroups. After review of the workshop report, the Committee decided to reorganize the scoping workshop workgroups into seven, new, issues-based working groups.

1. Shoreline Change
2. Estuarine Nutrient enrichment
3. Freshwater Quality
4. Water Quality (Contaminants only)
5. Visitor Use and Recreation
6. Animal and Plant Species and Habitats of Special Concern
7. Data management

Approximately five people were assigned to each working group by the Steering Committee, and at least one Steering Committee member acted as the group organizer. The groups were asked to meet to further develop plans for monitoring. They were asked to produce a written report by February 15, 2001 that included:

- review of existing Cape Cod protocols
- review of Gateway workgroup reports
- prioritize monitoring questions
- review candidate indicators
- evaluate existing monitoring programs
- develop scope of work to fill data gaps
- list potential cooperators
- estimate costs for 2001-2002
- report to Network

Of the seven working groups, only four groups met and submitted reports to the Network; shoreline change, estuarine nutrient enrichment, freshwater quality and data management. The shoreline change and estuarine nutrient enrichment groups, were the most successful in fulfilling the requests listed above. These two groups made a large effort to develop scopes of work that could be funded by the Network to begin acquiring the necessary background information for protocol development. Although the smaller working group approach only worked well in some cases, Network staff continued to move forward in developing projects to gather the necessary information in the areas of freshwater quality, species and habitats of concern, recreation use and visitor impacts and contaminants. Figure 8 illustrates the process that has taken place so far in developing a long-term monitoring program for the Network.

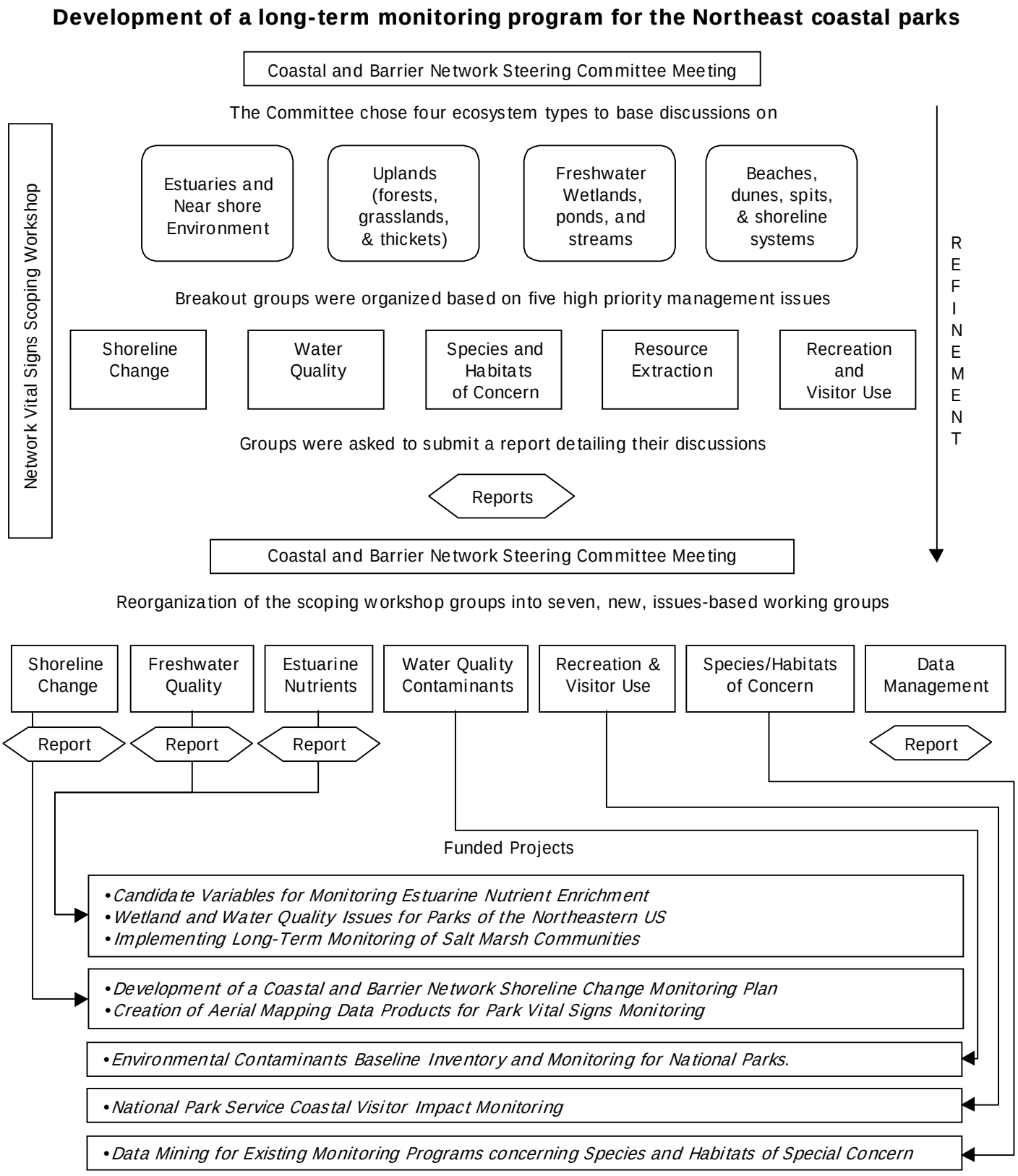

Figure 8. Steps taken in development of a Vital Signs Monitoring Program for the Northeast Coastal and Barrier Network.

Funded Projects

In FY01-02, the following projects were funded by the Network. The project title, investigators, and a brief abstract are listed below. For each of these projects the cooperators were asked to identify existing monitoring programs going on in each of the parks as well as programs being conducted by other federal, state, local and non-governmental organizations. Cooperators were asked to identify those programs which the Network could coordinate existing efforts with or share data and resources. They are also required to develop conceptual models showing the relationships between agents of change, stressors and ecosystem responses pertaining to the issues the monitoring protocol they are developing is based on.

Estuarine Nutrient enrichment and Freshwater Quality Projects

- *Candidate Variables for Monitoring Estuarine Nutrient Enrichment within the NPS Coastal and Barrier Network*, PI's: Blaine S. Kopp, USGS Patuxent Wildlife Research Center, Hilary A. Neckles, USGS Patuxent Wildlife Research Center, Charles T. Roman, NPS and Scott W. Nixon,University of Rhode Island Graduate School of Oceanography. This project includes a review of existing monitoring programs and activities relevant to the development of vital signs for estuarine water quality within the Coastal and Barrier Network parks. Candidate monitoring variables were identified for regional testing based on the conceptual model developed for the Cape Cod prototype monitoring program.

- *Wetland and Water Quality Issues for Parks of the Northeastern US: A Scoping Report for the Coastal and Barrier Network*. PI's: Mary-Jane James-Pirri, Graduate School of Oceanography, University of Rhode Island, Charles T. Roman, National Park Service. This is a two-year project. The report will summarize threats, establish how those threats are altering structure and function of wetlands. In addition, existing monitoring programs will be evaluated and improvements suggested if appropriate. Information from state 305(b) and 303(d) reports will be summarized and discussed in light of our need to identify pristine waters and impaired waters in the network.

- *Implementing Long-Term Monitoring of Salt Marsh Communities within the Northeast Coastal and Barrier Network of the National Park Service*, PI's: Mary-Jane James-Pirri, Graduate School of Oceanography, University of Rhode Island, Charles T. Roman, National Park Service.

Recreation and Visitor Impacts Projects

- *National Park Service Coastal Visitor Impact Monitoring*, PI's: Christopher Monz, Ph.D., Sterling College and Yu-Fai Leung, Ph.D., North Carolina State University. The first phase of this project, which is currently underway, involves a data mining effort to compile existing information on visitor issues and concerns based on a scientific literature review, interviews with park managers and site visits. This phase of the project will also include the selection of potential vital signs for visitor impact monitoring in the Network.

Water Quality (Contaminants) Projects

- *Environmental Contaminants Baseline Inventory and Monitoring for National Parks*. PI's: Mark Robson, Rutgers University, and Keith Cooper, Ph.D., Cook College, Rutgers University. The first phase of this project will include a review of existing contaminant data from all sources (State, EPA, NPS, Corps of Engineers, etc) synthesized into a report for each of the Network parks. Compounds will be ranked based on a risk assessment that will be conducted.

Shoreline Change Projects

- *Development of a Coastal and Barrier Network Shoreline Change Monitoring Plan.* PI: Mark Duffy, ASIS GIS coordinator. Mark was detailed to the Coastal and Barrier Network to oversee the development of the shoreline change monitoring plan for the Network.. This includes data mining, data development, needs assessment and protocol development. The Network provided funds to backfill at ASIS and support the GIS program in exchange for 75% of Mark's time and 25% of the backfill time. A written agreement was developed and signed by the Regional Coordinator and ASIS Superintendent.

- *Creation of Aerial Mapping Data Products for Park Vital Signs Monitoring within Northeast Region Coastal and Barrier Network.* PI's: John C. Brock and Laura J. Moore, USGS Center for Coastal Studies and Mark Duffy, National Park Service. This project will gather all existing NASA aerial mapping surveys of Coastal and Barrier Network parks, process the data using LaserMap software to produce survey-specific suites of GIS-compatible information products tailored to support vital signs monitoring. All previously collected LIDAR data sets for ASIS, GATE, CACO and FIIS will be processed to create a separate set of information products for each of the park data sets.

Species and Habitats of Concern Projects

- *Data Mining for Existing Monitoring Programs within the Network concerning Species and Habitats of Special Concern.* PI: Linda Arnold-Fabre,University of Rhode Island. Existing information on rare threatened and endangered species and habitats and keystone species in (or near) Network parks has been compiled and data obtained. Current monitoring programs going on within the Network parks, as well as region-wide monitoring programs information has been compiled for vertebrates and vascular plants. A report summarizing this information is available.

Each of these projects is in various stages of development (Figure 9). The salt marsh community monitoring project is in the implementation stage simply because the two protocols used for this project, monitoring nekton and vegetation communities, have been developed and implemented at the Cape Cod National Seashore as well as a number of USFWS properties along the coast. Therefore this component of the Network monitoring program is ready for implementation in the other seven Network parks.

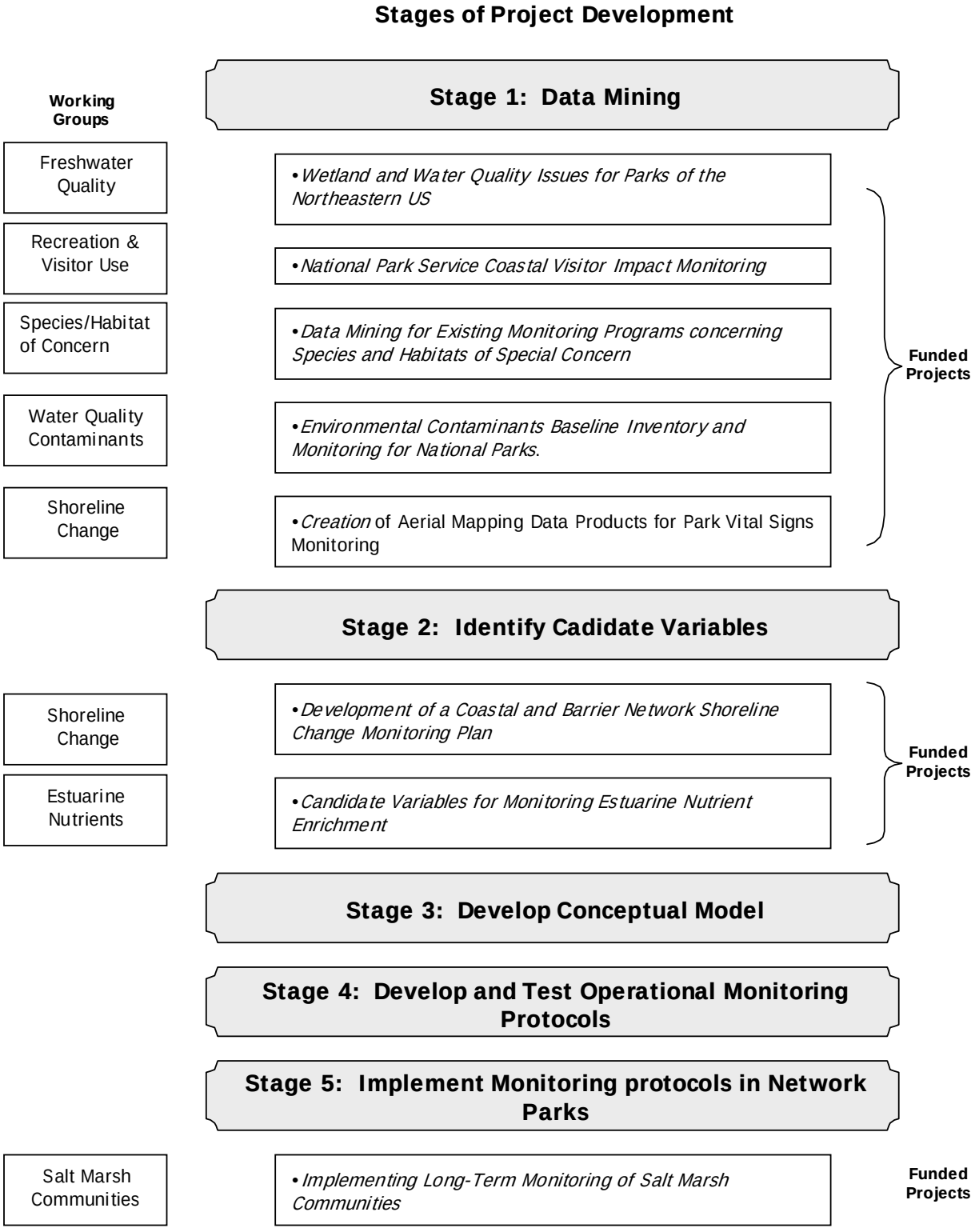

Figure 9. Stages of project development for the Northeast Coastal and Barrier Network Vital Signs Monitoring Program

DATA MINING RESULTS

For each of the projects listed above, the cooperators were asked to identify existing monitoring programs going on in each of the parks as well as other programs being conducted by other federal, state, local and non-governmental organizations. Cooperators were asked to identify programs by which the Network could coordinate existing efforts with or share data and resources. To date, the Network has received draft results of the data mining effort conducted by the PI's working on estuarine nutrient enrichment monitoring, shoreline change and species and habitats of concern. A summary of this information from these projects is provided below, the complete documents can be found at:

Data Minin -Estuarine Nutrient enrichment Project

The following is a review of existing monitoring programs and activities within the Northeast Coastal and Barrier Network parks that are relevant to the development of Vital Signs indicators for estuarine nutrient enrichment (Kopp et al., 2002)

Assateague Island National Seashore (ASIS)

Character of Park Estuarine Resources

Assateague Island National Seashore (ASIS) was established by Congress in 1965 to preserve the natural resources and recreational value of Assateague Island, Maryland and Virginia. The boundary of ASIS encompasses approximately 48,000 acres. Over 60% of the area is oceanic and estuarine habitat, including Chincoteague and Sinepuxent Bays (NPS 2000a). As an undeveloped barrier island, land-use within the park has much less influence on the nutrient enrichment status of these bays than does land use throughout the adjacent Maryland watersheds that drain into them.

The management and monitoring of estuarine natural resources at the park is a joint effort among many federal and state partners. The boundary of Assateague Island National Seashore encircles the NPS holdings, the US Fish and Wildlife Service's Chincoteague National Wildlife Refuge (VA portion of Assateague Island), and Maryland's Assateague Sate Park. Further, Sinepuxent Bay and the Maryland portion of Chincoteague Bay are managed under the Maryland Coastal Bays Program (MCBP) as a National Estuary Program (NEP) estuary. The MCBP identified five major environmental problems facing the coastal bays: degraded water quality, loss of habitats, changes in living resources, unsustainable growth and development, and poorly planned recreational use of the bays (MCBP 1999). Of these, degraded water quality due to nutrient and sediment enrichment was identified as the most pressing environmental problem. Consequently, the MCBP developed a comprehensive nutrient enrichment monitoring plan for the area (MCBP 1999). Over 70 existing and relevant monitoring programs within the coastal bays and their watersheds were reviewed for possible inclusion in the plan (MCBP 1998b). Implementation requires the continued participation of many of these monitoring partners (including National Park Service monitoring of estuarine water quality), and expanded or newly-created monitoring programs for many of the components. Implementation is coordinated by the Maryland Department of Natural Resources, Resource Assessment Service through a Monitoring Subcommittee of the Scientific and Technical Advisory Committee.

Conceptual framework for MCBP monitoring:

Three levels of monitoring are identified in the MCBP Nutrient enrichment Monitoring Plan: landscape monitoring and management action tracking (level I), stressor monitoring (level II), and response monitoring (level III). Although the monitoring plan is thorough for current needs and adaptable to future ones, a notable weakness is the exclusion of a significant portion of ASIS estuarine

habitat because of the political boundary between Maryland and Virginia. The MCBP Nutrient enrichment Monitoring plan stations maps are appended to this section.

Landscape Monitoring
Land use and land cover data are available from the NOAA C-CAP Coastal Change Analysis Program. Also, national land cover data (15 land classes) are available from the Multi-Resolution Land Characteristics Consortium from 1991 and 1992 imagery.

In addition, several sources of land use characterization data are identified in the nutrient enrichment monitoring plan, but are not yet being compiled in a meaningful format for tracking landscape level changes. Among these, rates of nutrient application are tracked by the Worcester County Cooperative Extension Service (CES) for some of the agricultural land. Crop acres and yields are compiled by the MD Office of Agricultural Statistics, and animal populations and manure production may be estimated using data from Worcester CES and Worcester Soil Conservation District.

Nutrient Stressor Monitoring
A National Atmospheric Deposition Program (NADP) station (MD18) is located within the boundary of ASIS, and has been in operation since the year 2000. The NADP protocol calls for weekly integrated samples to be collected and analyzed for dissolved inorganic nitrogen species. There is no permanent ongoing monitoring of groundwater loading, but USGS studies of groundwater discharge and nitrate loading have been conducted (Dillow and Greene 1999). Likewise, there is currently no ongoing monitoring of nutrient flux via surface water. There is, however, one USGS stage-discharge monitoring station in operation, and an expanded network has been proposed. This is scheduled to include event-triggered sampling for water chemistry. The bulk of the non-point sources of nitrogen to the Maryland Coastal Bays come from agricultural runoff (51%) and atmosphere deposition (32%)(MCBP 1998a). For point sources, there are five sewerage treatment plants and three permitted industrial discharges monitored under the National Pollutant Discharge Elimination System (NPDES) and Maryland Department of the Environment (MDE) Point Source Discharge Permits.

Ecosystem Response Monitoring

Water quality
The National Park Service has an extensive water quality monitoring program at ASIS dating back to 1987. Eighteen stations are sampled monthly throughout the year for a suite of water quality measures including nitrate+nitrite, ammonium, phosphate, silica, total nitrogen (not filtered), total phosphorus (not filtered), silica, total suspended solids, cholorphyll-a, b, and c, pheophytin-a, temperature, dissolved oxygen, specific conductance, pH, Secchi depth, light attenuation, and wind speed and direction. Half of the eighteen stations are in MD waters and half in VA. Station locations were selected primarily to insured that each embayment would be sampled, with attention to confluence areas around major tributaries. Secondary station selection criteria targeted areas with documented water quality problems; tertiary criteria addressed proximity to important living resources, habitats and related monitoring sites; quartenary criteria examined suitability of historical monitoring sites. The final suite includes representative stations from both near-shore and mid-channel areas.

In addition to discrete monthly monitoring, three permanent automated monitoring stations are in place. At these stations, tide height, dissolved oxygen, total suspended solids, temperature, conductivity, and pH are recorded hourly.

Review of additional ecosystem response monitoring programs

MD Coastal Bays Program Volunteer Monitoring
Maryland Coastal Bays Program established a volunteer water quality monitoring program in 1997. This program monitors approximately 30 sites in the Maryland portion of the coastal bays. These sites consist of a targeted list of tidal creek, canal, cove, and harbor sites that are accessible from the shore. Monitoring variables include salinity, pH, chlorophyll-a, and dissolved inorganic nutrients. The stations are visited two times per month from April through November, and monthly thereafter.

EMAP, Coastal 2000, National Coastal Assessment.
In 1993, two hundred sites were sampled in a stratified random sampling design, integrated with the Mid-Atlantic assessment. In 2000, MD DNR was awarded a 5-year grant from the US EPA to conduct assessments of the DE and MD coastal bays using protocols developed by the US EPA Environmental Monitoring and Assessment Program (EMAP) (54 water quality stations, and 29 fish trawl and seine stations). Among the suite of variables measured were dissolved oxygen, salinity, pH, temperature, depth, light attenuation, turbidity, transmissivity, Secchi depth, nutrients (full suite of nitrogen, phosphorus , and silica species), chlorophyll-a, phytoplankton species, benthos, neckton, submerged aquatic vegetation, macroalgae, and exotic species.

Other ecosystem response monitoring programs include:
Annual mapping of the distribution and biomass of submerged aquatic vegetation in Chincoteague Bay (R. Orth, Virginia Institute of Marine Science).
Macroalgae monitoring by the Maryland Department of Natural Resources (DNR). This program is starting its third year and the monitoring protocol is currently under review. Last year, over 600 stations in Maryland waters were sampled quarterly for species composition and biomass.
Harmful/nuisance phytoplankton blooms. Maryland DNR monitors fifteen stations for the presence of Aureococcus and Pfiesteria. Monitoring in 1999 and 2000 was conducted between May and July with some additional monitoring in the fall of 2000.
Nekton monitoring. Maryland DNR monitors 20 trawl stations monthly between April and October and 19 fixed seine stations in June and September. In addition, fish health stations were added as part of the comprehensive Pfiesteria monitoring program.
Fish Kill monitoring program. Maryland Department of the Environment maintains records on reported fish kills.

Colonial National Historical Park (COLO)

Character of Park Estuarine Resources

Colonial National Historical Park (COLO) consists of two significant land holdings, the Yorktown and Jamestown Units, connected by a narrow traffic corridor, the Colonial Parkway. In total, the park holds 9,300 acres of land within three separate local political jurisdictions: York County, James City County, and the City of Williamsburg. The park is located adjacent to a rapidly developing urban/suburban area. Other key park neighbors include a Coast Guard Reserve Training Center and three US Navy facilities (a weapons station, a supply center, and a fuel farm). The Yorktown unit sits across the York River from the Virginia Institute of Marine Science (VIMS), and is characterized by sandy /gravely shore in an urban setting. The estuarine habitat is dominated by the lower York River, but the park also abuts a tidal creek estuary to the east, the West Branch of Wormley Creek. The Jamestown unit occupies all of Jamestown Island on the northeast bank of the lower James River. The estuarine habitat at Jamestown is dominated by the lower James River on one side, and by Sandy Bay, the Back River, and The Thorofare on the other. Jamestown Island, which is managed jointly by NPS and the Association for the Preservation of Virginia Antiquities (APVA), is low in elevation and dominated by wetlands and tidal creeks. The Jamestown unit is itself undeveloped; however, the

Powhatan Creek watershed, which drains into Sandy Bay and The Thorofare, is under tremendous development pressure. A nutrient reduction strategy and watershed management plan was drafted in 2001 to address threats posed by additional development (James City County 2001). The Colonial Parkway is a narrow corridor of park property passing over seven tidal creek systems. These are (from Jamestown to Yorktown) Powhatan Creek, Mill Creek, College Creek, Halfway Creek, King Creek, Felgate's Creek, and Indian Field Creek.

Currently, NPS conducts no ongoing estuarine habitat or water quality monitoring at COLO. It is has, however, initiated a process for developing a long-term surface water quality monitoring program (Project Statement COLO-N-601.503). Part of this planning effort included a review of relevant water quality monitoring activities within or near the park that were archived in the EPA's Storage and Retrieval (STORET) data archive. Those sites with immediate relevance to the park's estuarine habitat and water quality are identified on the station map (figure attached). Of 26 stations identified by the data search, only eight had good multi-year data for water quality. Measured parameters were not consistent between stations or sampling events, but typically included most of the following: temperature, conductivity, dissolved oxygen and dissolved inorganic and total nitrogen and phosphorus. Overall, the internal review concluded that there are too few stations in and near COLO, and too few measured parameters, to adequately describe water quality within the park (C. Rafkind, unpublished). The bulk of monitoring activities in park environs are conducted along the major rivers flowing past Jamestown and Yorktown park units. In 2000, the Commonwealth of Virginia prepared nutrient reduction strategies for both the James and York Rivers (VA 2000a, VA 2000b). Nutrient loading to these rivers is well understood; point sources are directly monitored and in situ nutrient concentrations are measured by the Virginia Department of Environmental Quality.

Landscape Monitoring

Land use and land cover data are available from the NOAA C-CAP Coastal Change Analysis Program. Also, national land cover data (15 land classes) are available from the Multi-Resolution Land Characteristics Consortium from 1991 and 1992 imagery. National Wetlands Inventory Data, published by the US Fish and Wildlife Service, is available for this area, but comes from photography taken between 1970 and the early 1990s.

Nutrient Stressor Monitoring

No NADP site is located in the immediate area. The closest is MD18 at ASIS or VA24 in Prince Edward County, VA. However, the Atmospheric Integrated Research Monitoring Network (AIRMoN) is a network of the NADP that collects daily deposition samples. The closest AIRMoN station is number MD15 on Smith Island in the main stem of the Chesapeake Bay. It is operated by the US EPA and the Chesapeake Bay Program. Additionally, the Virginia Chesapeake National Estuarine Research Reserve (CBNERR-VA), located across the York River at VIMS, does conduct continuous meteorological/weather monitoring and is interested in the possibility of expanding its program to include atmospheric deposition monitoring.

Ecosystem Response Monitoring

Chesapeake Bay National Estuarine Research Reserve, Virginia
The CBNERR-VA has conducted monthly discrete water quality monitoring at a minimum of four stations along the lower York River since 1997. Parameters for this program (NERR 2001) include chlorophyll-a, Secchi depth, diffuse attenuation coefficient of photosyntheticly active radiation (PAR) and nutrients (ammonium, nitrate, nitrite, and phosphate). The reserve is planning to add additional

nutrients species to their suite of analytes in the near future (particulate nitrogen and phosphorus, total dissolved nitrogen and phosphorus, particulate and dissolved organic carbon, and silica). These discrete samples support continuously-operating automated sampling boys at the same four stations. Data sonds at each station log temperature, salinity, turbidity, total suspended solids, dissolved oxygen, and pH.

Virginia Department of Environmental Quality, Office of Water Quality Assessment
Numerous permanent stations on both the lower York and lower James Rivers are visited a minimum of six times per year. In coordination with the EPA National Coastal Assessment, probabilistic sampling was scheduled to be added for the 2002 sampling year. This program interfaces with the Chesapeake Bay Program and addresses DEQ and Bay Program variables: pH, dissolved oxygen, temperature, salinity, Secchi depth, diffuse attenuation coefficient of PAR, total suspended solids, nitrate, nitrite, ammonium, phosphate, total nitrogen, total phosphorus, silica, chlorophyll-a, species composition of phytoplankton, zooplankton and benthic fauna, five-day biochemical oxygen demand, chemical oxygen demand, and bacteriological monitoring.

Review of additional monitoring programs

Other ecosystem response monitoring programs include:
Annual mapping of the distribution and biomass of submerged aquatic vegetation (R. Orth, VIMS).
VIMS Juvenile Fish and Blue Crab Trawl Survey. Started in 1955, currently occupies 60 stations monthly.
Remote sensing program for chlorophyll-a throughout the Chesapeake using Ocean Data Acquisition System (ODAS) satellite sensors since 1986, then SEAWIFS aircraft simulator (SASII) instruments since 1997. Mapping is incomplete in tributaries.
The Alliance for Chesapeake Bay (ACB) Citizen's Monitoring Program (CBCMP) began in 1985 and monitors sites along the York and James Rivers near the park. Shoreline sites are monitored weekly for DO, pH, and turbidity. Limited nutrient data have also been collected on occasion.
The VIMS "Shoal Run" occupies a station near COLO (Yorktown end) and measures dissolved inorganic nitrogen and phosphorus, total suspended solids, chlorophyll-a, and the diffuse attenuation coefficient of PAR.
VA Chesapeake Bay Program main stem phytoplankton monitoring for nuisance/harmful species since 1985.
VA Chesapeake Bay Program main stem benthic monitoring. The state of Virginia and the US EPA Chesapeake Bay program have cooperatively monitored benthic fauna and sediment composition in the VA portions of the main stem and tributaries since 1985. This includes the lower York and James Rivers, but not the small tidal creeks of COLO. A probability-based sampling design was layered over the fixed station approach starting in 1994.

George Washington Birthplace National Monument (GEWA)

Character of Park Estuarine Resources

George Washington Birthplace National Monument (GEWA) is a 550-acre unit of the National Park Service located along the tidal reaches of the Potomac River in Westmoreland County, Virginia. GEWA lies within the Potomac River watershed, and consequently, the greater Chesapeake Bay watershed. The Potomac shoreline, which delineates the northern boundary of the monument and also the border between Virginia and Maryland, has a tidal range of approximately 1 meter at GEWA, and a salinity range of 0.5 to 17‰ (Belval et al. 1997 and citations therein). Erosion along the Potomac shoreline is severe and represents significant threats to the monument. The low terrace soils of poorly-

drained silty sand and clay form steep embankments, 5-7 m high, along the river. These are currently receding at the rate of 30-100 cm per year (R. Morawe personal communication). Three small sub-basins drain into the Potomac at GEWA. These are Popes Creek, Bridges Creek, and a third unnamed creek. The combined area of these sub-watersheds is approximately 13,500 acres (Belval et al. 1997). The largest of these (and most significant to GEWA) is Popes Creek. Land use in the three sub-basins is largely agricultural, and park abutters raise cattle (which are allowed to wade in the creeks), and make use of bio-solids to fertilize their fields. Since there are no known point sources for bacteriological contamination within Popes Creek, farming and other non-point sources are most likely responsible for the fecal coliform contamination that has kept the creek closed to shellfishing since 1972 (Belval et al. 1997). Nonetheless, results of sediment contaminant studies (organics and metals) indicate that Popes Creek is among the most pristine creeks in the Chesapeake (R. Morawe personal communication), and the system is used as a reference location for numerous studies considering the effects of agricultural runoff on receiving waters and their geochemistry (see Wilde et al. 2000 and references therein).

Landscape Monitoring

Land use and land cover data are available from the NOAA C-CAP Coastal Change Analysis Program. Also, national land cover data (15 land classes) is available from the Multi-Resolution Land Characteristics Consortium from 1991 and 1992 imagery. National Wetlands Inventory Data, published by the US Fish and Wildlife Service, is available for this area, but comes from photography taken between 1970 and the early 1990s.

Nutrient Stressor Monitoring

No NADP stations are located within the boundary of GEWA. The closest NADP sites are MD13 in Wye, MD, and VA00 in Charlottesville. However, the Atmospheric Integrated Research Monitoring Network (AIRMoN) is a network of the NADP that collects daily deposition samples. The closest AIRMoN station is number MD15 on Smith Island in the main stem of the Chesapeake Bay. It is operated by the US EPA and the Chesapeake Bay Program.

There is no permanent ongoing monitoring of groundwater loading, but there is a USGS gauging well near the park. Within the park, there are an old shallow dug well and a modern production well for park use. Limited groundwater quality data are available for the monitoring well from the 1970's and currently from the GEWA production well (unpublished files USGS VA District Office, Belval et al. 1997). There was also a 1944 study of groundwater quality (from a spring at GEWA) indicating elevated nitrogen concentrations (Sinnot 1969). There are four permitted point-source discharges in Virginia within 3 miles of GEWA that are monitored under the National Pollutant Discharge Elimination System (NPDES). Only one of these, the Town of Colonial Beach STP, is a major discharger (2,000,000 gal/d). The rest are permitted for between 2,000 and 20,000 gallons per day of sewerage effluent.

Ecosystem Response Monitoring

Virginia Department of Environmental Quality, Office of Water Quality Assessment

The streambed of the Potomac River falls within the state boundaries of Maryland and is monitored by that state. Tributary creeks and streams originating in Virginia, however, are monitored by the Virginia Department of Environmental Quality (VA DEQ) for federal Clean Water Act compliance. Starting in July 1997, a single station was added in Popes Creek to the list of VA DEQ monitoring stations (VA DEQ station number 1APOP000.38). It is sampled six times per year for a large suite of variables including the following: pH, dissolved oxygen, temperature, salinity, total suspended solids,

nitrate, nitrite, ammonium, phosphate, total nitrogen, total phosphorus, sediment organic matter, and bacteriological monitoring. There is another DEQ station farther upstream at the VA Route 3 bridge.

State of Maryland
Maryland's basic statewide water monitoring activities are conducted principally by two agencies. Water monitoring programs within the Department of the Environment (MDE) address regulatory issues (e.g., permit compliance and modeling, evaluation of water quality standards, shellfish sanitation, Total Maximum Daily Loads) while those programs within the Department of Natural Resources (DNR) address water quality and aquatic resource issues. Since 1984, the EPA Chesapeake Bay Program has funded the State's Water Quality Monitoring efforts in the main-stem bay. Two Potomac River stations within the vicinity of GEWA are maintained for federal Clean Water Act compliance. These include station XDC1706 at the US Route 301 bridge, and station MLE2.2 at Ragged Point. A full suite of dissolved organic and inorganic nutrients are monitored monthly at these stations as well as pH, temperature, chlorophyll-a, salinity, and Secchi depth. Phytoplankton community structure is examined monthly at a site upstream of GEWA at Indian Head; however this is over 50 km away. Benthic community structure and sediment organic matter are monitored annually using both fixed stations and probability-based sampling throughout the Potomac River. None of the fixed benthic stations are located directly adjacent to GEWA, but there are five stations within 20 km of GEWA: stations 43, 44,47, 51, and 52.

Review of additional monitoring programs

Other ecosystem response monitoring programs include:
Annual mapping of the distribution and biomass of submerged aquatic vegetation (R. Orth, VIMS).
Remote sensing program for chlorophyll-a throughout the Chesapeake using Ocean Data Acquisition System (ODAS) satellite sensors since 1986, then SEAWIFS aircraft simulator (SASII) instruments since 1997. Mapping is incomplete in tributaries.
Alliance for CB Citizens Monitoring Program (ACBCMP). One site is located within Popes Creek at GEWA (since 1991), one site is approximately 4 miles downstream in the Potomac River, and one approximately 20 miles upstream. ACBCMP conducts weekly summertime monitoring for temperature, salinity, pH and dissolved oxygen.
Chesapeake Bay Program main stem phytoplankton monitoring for nuisance/harmful species since 1985.

Gateway National Recreation Area (GATE)

Character of Park Estuarine Resources

Gateway National Recreation Area (GATE) consists of 26,645 acres of coastal uplands, freshwater ponds, marshes, bays, beaches, and mudflats. Established in 1972, it is divided into four geographically separate units that constitute some of the largest and most significant natural areas remaining in the metropolitan New York City area. They include the Jamaica Bay/Breezy Point unit, the Sandy Hook unit, and the Staten Island unit.

Jamaica Bay and Breezy Point are considered separate units of GATE in the enabling legislation of 1972, but are generally treated as districts within a single unit (since Breezy Point constitutes the ocean-side barrier of Jamaica Bay). Three bathing beaches are located along Breezy Point district (Breezy Point Tip, Fort Tilden and Jacom Riis Park). The Jamaica Bay Wildlife Refuge district consists of 9,115 acres of marsh, wetlands, ponds and forested areas (Muzio and Rubel 1993). It is surrounded by the densely urban New York City boroughs of Brooklyn and Queens, and by the

Rockaway Peninsula. Jamaica Bay's estuarine waters are heavily impacted from roadway stormwater runoff, wastewater and sewerage treatment plant (STP) effluent, raw sewerage from combined sewerage overflows (CSOs), landfill leachage, and contaminants from JFK International Airport. STPs discharge an average of approximately 3.2x108 gal/day directly into Jamaica Bay, and over 2000 CSOs in Jamaica Bay become active with even modest amounts of rainfall (G. Frame, personal communication). In addition to nutrient enrichment concerns, marsh loss and coastal sea level rise present a clear and pressing threat to this ecosystem (NPS 2001).

The Sandy Hook Unit is a 10-km long peninsula attached to the mainland of the state of new Jersey, 26 km due south of Manhattan. 1,680 acres in size, Sandy Hook varies in width from 100 m to 1.5 km, and has approximately 10.5 km of ocean shoreline (Muzio and Rubel 1993). It is heavily influenced by the Atlantic Ocean as well as the Hudson River and the Navesik River. Sand transport and shoreline stabilization are significant issues for this unit of GATE.
The Staten Island Unit is located in Lower New York Harbor and, like the Sandy Hook Unit, is heavily influence by both the Hudson River and Atlantic Ocean. It is located on Staten Island's southeast shore and consists of an approximately five-mile stretch of contiguous beach (Great Kills Beach, Oakwood Beach, New Dorp Beach, Midland Beach and south Beach). Extending landward of the beaches are Miller Field and Fort Wadsworth. The northern extent of the Unit is located in Fort Wadsworth at the Verrazano Narrows Bridge, and the southern end is Crookes Point at Great Kills Harbor. Although enabling legislation designated this stretch of beach as part of GATE, exact park boundaries are vague, and some of the beach property is still under city ownership and control. Hoffman and Swineburn Islands, also part of GATE, are functionally associated with the Staten Island Unit.

All submerged lands within one quarter mile of any Park-owned shoreline are explicitly included in the enabling legislation for GATE. In New Jersey, however, the state claims ownership of the bottom, and consequently GATE does not regulate submerged lands at the Sandy Hook Unit.

Landscape Monitoring

Land use and land cover data are available from the NOAA C-CAP Coastal Change Analysis Program and the Multi-Resolution Land Characteristics Consortium. For the latter, mapping is available from 1991 and 1992 imagery, and land is classified into 15 classes.

Nutrient Stressor Monitoring

There are no NADP or AIRMoN stations for monitoring atmospheric deposition of nutrients in the immediate vicinity of GATE. The closest NADP site is NY99 at West Point, so estimates for deposition at the park would necessarily rely on NADP data contoured from all the regional sites. For point source discharges, National Pollutant Discharge Elimination System (NPDES) permits and compliance monitoring data are available from the New York State Department of Environmental Conservation. There are four major permitted STPs discharging into Jamaica Bay, with an average daily discharge of 3.2x108 gal/day, and another STP that discharges adjacent to the Staten Island Unit. Monthly monitoring reports are available directly from the New York City Department of Environmental Protection (NYC DEP) Bureau of Wastewater Treatment. Additionally, NYC DEP has a hydrodynamic model for storm water discharge into Jamaica Bay (SWM).

Ecosystem Response Monitoring Programs

Water quality

GATE initiated a water quality monitoring program in 1981, and has maintained a consistent sampling regimen for a network of up to 30 stations since 1997 (NPS 2000b). As a National Recreation Area, Gateway's monitoring program is focused on public health concerns for "contact recreation." This is particularly true for the Sandy Hook and Staten Island Units, where the program is exclusively bacteriological in nature. Monitoring is conducted weekly from mid-May to September and approximately monthly thereafter at six stations in the Sandy Hook Unit, eight stations in the Staten Island Unit, and at 9-15 bay stations and 2 Atlantic beach stations in the Jamaica Bay/Breezy Point Unit. Additionally, the park monitors the following environmental parameters in Jamaica Bay: chlorophyll-a, salinity, dissolved oxygen, pH, temperature, Secchi depth, nitrate plus nitrite, and orthophosphate.

In addition to this discrete sampling program, three permanent automated monitoring stations are scheduled for deployment this year in Jamaica Bay through a cooperative agreement with Crusader Technologies. These will include sensors for temperature, pH, turbidity and dissolved oxygen. They may also include fluorometers for measuring chlorophyll-a, but are not scheduled to include salinity/conductivity sensors.

The Interstate Environmental Commission (IEC) also monitors water quality within the park. Their program includes 67 stations (33 long term) in NY/NJ Harbor and Long Island Sound (station map attached) with bi-weekly sampling during the summer and monthly during the rest of the year. Their suite of variables includes temperature, salinity, dissolved oxygen, chlorophyll-a, biochemical oxygen demand, turbidity, total organic carbon and a full suite of organic and inorganic nitrogen and phosphorus species.

The third major monitoring program relevant to GATE is conducted by the New York City Department of Environmental Protection. Eight stations (site maps attached) are monitored in Jamaica Bay plus, one at the Hudson River Narrows (representative of the Staten Island Unit unit), and several in lower NY Harbor (but north of the Sandy Hook Unit). The stations are sampled weekly from mid-may through September, and once or twice per month throughout the rest of the year. Monitoring variables include temperature, salinity, pH, dissolved oxygen, chlorophyll-a and Secchi depth.

benthos/neckton monitoring

GATE and the US Fish and Wildlife Service have conducted the Jamaica Bay Fisheries Survey since 1985. This survey includes 15 otter trawl sites, nine gill net sites, and six beach seine sites. The monitoring frequency is intermittent, but occurs approximately monthly (NPS 1991).

Other ecosystem response monitoring programs and information

New York / New Jersey Harbor is National Estuary Program (NEP) estuary, and all the units of GATE fall within the NEP study boundaries. Additionally, the NOAA system of National Estuarine Research Reserves (NERRs) includes a Hudson River NERR, which has land holdings approximately 20 miles upriver from the Staten Island unit. In addition to NPS monitoring, natural resources are monitored by the City of New York through their Harbor Survey Program, and the Interstate Environmental Commission (a collaboration between the states of New York, New Jersey and Connecticut and formerly called the Interstate Sanitation Commission). There are voluminous descriptions of research programs and monitoring programs for GATE in general, and Jamaica Bay in particular. The most notable sources of additional information and monitoring data come from the Jamaica Bay Ecosystem Restoration Team, and EMAP Coastal 2000. The latter conducted a probability-based survey of Jamaica Bay in 2001. Also, HydroQual Inc. has produced a Jamaica Bay Nutrient enrichment Model.

The NY/NJ Harbor Estuary Program has drafted a Comprehensive Conservation and Management Plan for this estuary (NY/NJ HEP1996) which includes a mandate to develop a monitoring strategy for nutrients and nutrient enrichment.

Fire Island National Seashore (FIIS)

Character of Park Estuarine Resources

Fire Island National Seashore (FIIS) is a 19,300-acre park on the South Shore of Long Island, New York. Approximately 11,000 of these acres are submerged lands in Great South Bay and Moriches Bay (80%) and the Atlantic Ocean (20%). Not included in the above acreage, but within the boundary of FIIS, is the Smith Point County Park located at the eastern end of Fire Island. At the western end of Fire Island, outside the park boundary, is the Robert Moses State Park. The character of FIIS is varied, and includes both wilderness area (Otis Pike Wilderness Area) and 17 local communities. These are largely summer communities since ferry service is only in operation from May to October. However, FIIS is situated only 55 miles from downtown Manhattan, and lies in the midst of the highly urbanized and suburbanized northeast seaboard, one of the most densely populated regions in the nation. Consequently, land-use within the park has much less influence upon the nutrient enrichment status of Great South Bay and Moriches Bay than does the land use throughout the larger Long Island watersheds that drain into them. Most of the tidal exchange for GSB occurs through the Fire Island Inlet (SSER 2000). Groundwater constitutes 11% of the fresh water supply to Great South Bay (Pluhwoski and Kantrowitz 1964, SSER 2000), and groundwater concentrations of nitrogen have increased with upland development in non-sewered areas (Leamond et al. 1992). Atmospheric deposition constitutes 26% of the nitrogen load to Great South Bay (Schlenk and Wise 1999), and the remainder comes from surface water and point source discharges. The National Estuarine Nutrient enrichment Assessment (Bricker et al. 1999) lists Great South Bay as exhibiting high eutrophic conditions. Factors contributing to this listing include high levels of chlorophyll-a, moderate loss of submerged aquatic vegetation, and moderate nuisance algal blooms.

FIIS does no monitoring of its estuarine resource. Brown tides are considered a dominant perennial problem in Great South Bay, and primary production is thought to be limited by temperature and light (Schubel et al. 1991). Based upon the relative concentrations of dissolved inorganic nutrients, however, Raposa (1997) suggests that phosphorus may be limiting for the bayside around FIIS Wilderness Area.

In 1993, the New York State Legislature created the South Shore Estuary Reserve (SSER) and the South Shore Estuary Reserve Council to manage it. The SSER extends both to the east and west of FIIS, including all of the southern coastal embayments on Long Island from West Bay in Hampstead to Shinnecock Bay in South Hampton. Although SSER is not a National Estuary Program estuary, it's organization and resource-management strategies are consistent with those of the NEP. The SSER Council was tasked with developing a Comprehensive Management Plan for the reserve. As a component of its management plan, the Council commissioned a coordinated ecosystem monitoring strategy (SSER 2000). The SSER Council is formed of representatives from the state, adjacent cities, town, villages, counties, and interest groups. Enacting legislation did not, however, explicitly allow for participation by the National Park Service, and FIIS had not been represented as a council member or designee (SSER 2001).

Landscape Monitoring

Land use and land cover data are available from the NOAA C-CAP Coastal Change Analysis Program. Also, national land cover data (15 land classes) is available from the Multi-Resolution Land Characteristics Consortium from 1991 and 1992 imagery. The planning agencies for Suffolk County and Nassau County track land use, and, in particular, track the proportion of the counties covered by impervious surfaces. Every five years, New York State Department of Environmental Conservation (NYS DEC) conducts aerial photographic surveys for wetland delineation.

Nutrient Stressor Monitoring

There are no NADP or AIRMoN stations located in close proximity to FIIS to track atmospheric deposition of nutrients at the park. Estimates for deposition at the FIIS would necessarily rely on NADP data contoured from all the regional sites.

Point source loading of nutrients to SSER is traceable through National Pollutant Discharge Elimination System (NPDES) permits and compliance monitoring data, available from NYS DEC. Effluent volume and quality are reported to the state in monthly Discharge Monitoring Reports. Surface water loading of nutrients used to be monitored by the USGS, however nutrient concentration monitoring in streams and tributaries flowing into GSB was abandoned by the Survey in 1996. Water stage in streams continues to be monitored by the USGS, and stage-discharge relationships are maintained for eight of the tributaries emptying into the SSER. NYS DEC conducts Rotating Intensive Basin Surveys (RIBS) of stream water quality (including nutrients). Together with USGS flow data, this could be used to estimate surface water nutrient loading. Likewise, the Long Island Regional Planning Board also collects limited nutrient data (total nitrogen) for its Land Use and Stream Assessment Program, and the South Shore Estuary Watch (SSEW) began monthly monitoring of seven tributary streams to the SSER in 1999.

Ecosystem Response Monitoring

Estuarine water quality

The most extensive water quality monitoring program in the SSER is conducted by the Suffolk County Department of Health Services, Bureau of Marine Resources. This program was started in 1977. Data are gathered at 42 stations in the estuary, biweekly from May to September and monthly thereafter. Monitoring variables for this program include temperature, salinity, dissolved oxygen, Secchi depth, a full suite of organic and inorganic nitrogen and phosphorus nutrients plus inorganic silica, chlorophyll-a (total and nano-plankton), Aureococcus abundance, and bacteriological monitoring. Twenty of the stations for this program fall within, or in close proximity to, FIIS.

Outside the immediate domain of FIIS, but within the SSER, the town of Hampstead conducts its East Bay and West Bay monthly sampling surveys at 30 stations. Monitoring variables for this program include Secchi depth, temperature, salinity, dissolved inorganic nitrogen and phosphorus, particulate organic matter, chlorophyll-a, dissolved oxygen, biochemical oxygen demand, and bacteriological monitoring.

Review of additional ecosystem response monitoring programs

Other ecosystem response monitoring programs include:

Pfiesteria monitoring by NYC DEC, Suffolk County and the town of Hampstead. This program was started in 1999 at 27 stations in Suffolk County and Hempstead and includes temperature, salinity, nutrients, total suspended solids, and chlorophyll-a in its sampling suite. Sampling occurs 1-3 times starting in July.

17. NYS DEC conducts aerial photographic surveys every five years for wetland delineation. These photographs generally penetrate to a depth of two meters or less, but could be used for limited mapping

of Zostera marina. This could be checked against other eelgrass mapping efforts such as that of Jones and Shubel (1980) or NPS SAV maps generated from 1992 photography (available from the NPS office of GIS).

Sagamore Hill National Historic Site (SAHI)

Character of Park Estuarine Resources

Sagamore Hill National Historic Site (SAHI) is a small, 83-acre cultural/historical park on Cold Spring Harbor which is a branch of Oyster Bay on the north shore of Long Island, just twenty five miles east of New York City. The park's approximately 200m of shore frontage is largely a beach of shell hash, behind which there is a small impounded salt marsh that is flushed by a tidal creek connecting it to Cold Spring Harbor. Land use in the watershed draining directly into the tidal marsh is dominated by the park itself, and by a few large neighboring private estates. The Oyster Bay – Cold Spring Harbor complex lies in the midst of the highly urbanized and suburbanized northeast seaboard, one of the most densely populated regions in the nation. The Long Island Sound Study (LISS), a cooperative effort of federal, state and local governments concluded that low dissolved oxygen is the most acute threat to the health of the Long Island Sound ecosystem. Friends of the Bay (FOB), a local advocacy and monitoring group, reported that approximately half of its weekly monitoring surveys of Cold Spring Harbor during the summer of 2000 revealed dissolved oxygen concentrations that did not meet the New York State minimum standard of 5.0 mg/l for Class SC water, the lowest classification suitable for primary contact recreation such as swimming (FOB 2001). The lowest dissolved oxygen level recorded in Cold Spring Harbor for 2000 was 1.24 mg/l, causing it to fail even the lowest standard for Class SD water. This is the water class designation used where no contact recreation is appropriate, and the water is suitable for fish survival only. Nevertheless, this embayment, much of which falls within a 3,200-acre National Wildlife Refuge, is considered the cleanest in western Long Island Sound, and supplies up to 90% of the annual New York State oyster harvest (FOB 2001).

Landscape Monitoring/Tracking

Land use and land cover data are available from the NOAA C-CAP Coastal Change Analysis Program. Also, national land cover data (15 land classes) is available from the Multi-Resolution Land Characteristics Consortium from 1991 and 1992 imagery.

Nutrient Stressor Monitoring

There are no NADP or AIRMoN stations for monitoring atmospheric deposition of nutrients in the immediate vicinity of SAHI. The closest NADP site is NY99 at West Point, so estimates for deposition at the park would necessarily rely on NADP data contoured from all the regional sites. New York and Connecticut have identified Long Island Sound as "water quality limited" due to hypoxia. Provisions of the federal Clean Water Act and EPA's implementing regulations thus required that a total maximum daily load (TMDL) be established for nitrogen to Long Island Sound. As part of this process, current loading budgets were developed for Long Island Sound (LISS 2000). National Pollutant Discharge Elimination System (NPDES) permits and compliance monitoring data are available from the New York State Department of Environmental Conservation, Division of Water, to track loading to Oyster Bay from sewerage and industrial discharges. Currently there is a single municipal sewerage treatment plant that discharges in the embayment, and four smaller permitted discharges.

Ecosystem Response Monitoring

Friends of the Bay, Oyster Bay, NY
FOB was formed in 1987 and started it's water quality sampling program in response to cutbacks by the Suffolk and Nassau County Departments of Health. At present, FOB conducts the only routine ecosystem response monitoring in Oyster Bay and Cold Spring Harbor. Six stations (two in Cold Spring Harbor) are occupied weekly from May through October. Temperature, salinity, and dissolved oxygen are measured at 1m intervals through the water column, Secchi depth is determined, and a surface water sample is collected for bacteriological analysis. Stations are occupied within several house of dawn in order to capture daily oxygen minima. FOB has considered building upon their program, and may in the near future add dissolved inorganic nutrients, pH, and apparent color to their suite of monitoring variables.

Review of additional monitoring programs

Other ecosystem response monitoring programs include:
Interstate Environmental Commission (IEC). Formerly the Interstate Sanitation Commission, this organization represents NY, NJ, and CT. They monitor 67 stations (33 long term) in NY/NJ Harbor and LI Sound. Sampling frequency is bi-weekly during the summer, and monthly during the rest of the year. Variables include temperature, salinity, dissolved oxygen, chlorophyll-a, turbidity, total organic carbon, and a full suite of nitrogen and phosphorus nutrient species. There are no stations in Oyster Bay or Cold Spring Harbor, but there are representative stations for Long Island Sound.
Suffolk County Department of Health used to run an extensive monitoring program, but it was severely cut back in 1998. Monitoring had included a full suite of nitrogen and phosphorus nutrient species, dissolved oxygen, chlorophyll-a, Aureococcus, Secchi depth, temperature, salinity, total suspended solids, total organic carbon, dissolved organic carbon, and bacteriological monitoring. Cutbacks by the county are what instigated monitoring by Friends of the Bay.

Cape Cod National Seashore (CACO)

Character of Park Estuarine Resources

Cape Cod is a large glacial peninsula that extends 96.5 km into the Atlantic Ocean from the coast of Massachusetts. Cape Cod National Seashore (CACO) is located in Barnstable County on the outer cape. It was established in 1961 and contains 18,063 ha of marine, estuarine, freshwater, and terrestrial ecosystems. Much of the estuarine habitat at CACO is associated with two large coastal lagoon systems. Pleasant Bay, 7,285 acres in area, is the largest bay contiguous to the Seashore. It is isolated from the Atlantic Ocean by a barrier beach greater approximately12 km in length (known as Nauset Beach in Orleans and North Beach in Chatham), which is wholly situated within the boundary of the Cape Cod National Seashore. The other large coastal lagoon, Salt Pond, is a forty-foot deep glacial kettle hole that has been breached and filled with seawater.

Barnstable County is among the fastest growing counties in the northeastern U.S. During the period from 1980 to 1990, the population grew roughly five times faster than the state as a whole, then again almost four times faster during the period from 1990 to 2000 (US census data). Projections for the period from 2000 to 2010 anticipate a population increase of another 25% while the state grows by approximately 5.5% (MISER 1999). In 1990, in the wake of the unprecedented growth of the 1980s, the Cape Cod Commission was created by an act of the Massachusetts General Court and confirmed by Barnstable County voters. It was established as a regional planning and regulatory agency to prepare and implement a regional land use policy.

The National Park Service selected CACO to serve as a prototype monitoring park for the Atlantic Coastal and Barrier Island network. The USGS-Biological Resources Division, in collaboration with the NPS, has been responsible for designing and testing the prototype. The protocol for estuarine nutrient enrichment has been developed and evaluated under the direction of Dr. Charles Roman of the NPS (formerly with the USGS) and Dr. Barbara Nowiki of the University of Rhode Island. The final product in currently in draft.

Landscape Monitoring

As with all the network parks, land use and land cover data are available from the NOAA C-CAP Coastal Change Analysis Program. Also, national land cover data (15 land classes) are available from the Multi-Resolution Land Characteristics Consortium from 1991 and 1992 imagery. In addition, changing land use patterns will be monitored in terms of (a) conversion of summer to all year round status, (b) municipal water use records, and (c) land use/zoning surveys. The Cape Cod Commission assembles most of these data sets.

Nutrient Stressor Monitoring

A National Atmospheric Deposition Program (NADP) station (MA01) is located within the boundary of CACO at the NPS North Atlantic Coastal Lab and has been in operation since 1981. This allows for monitoring of wet deposition of nutrients in CACO. Because of the sandy soils and a burgeoning number of individual septic disposal systems, ground water poses the greatest threat of delivering excess nutrients to the salt ponds and coastal lagoons of CACO. Nutrient loading has therefore been tested as part of the prototype development. In the experimental phase, CACO established 10 sites throughout the Seashore and on a seasonal basis, and monitored groundwater input (using seepage chambers) and nitrate concentration to yield N-loading. Currently, they are evaluating within site, between site, and seasonal variability to determine if this is an appropriate method for inclusion in a long-term monitoring framework.

Ecosystem Response Monitoring

As part of prototype development, CACO established numerous water quality monitoring stations throughout the Seashore, and on a monthly basis sampled inorganic nutrients, chlorophyll-a, temperature, and salinity. Samples were gathered at three depths (surface, middle, bottom), and on 3 simultaneous days in order to account for day-to-day variability. These data are being analyzed to establish variability within sites, with depths, and with seasons. The monitoring protocol will also likely include some degree of continuous dissolved oxygen monitoring in select estuarine basins with long flushing times and where dissolved oxygen problems are anticipated.

Macroalgae species composition and abundance (biomass) was evaluated during the experimental phase of protocol development. A gradient of sites was established (from developed portions of estuaries to undeveloped portions) where species composition and biomass (dry weigh) were measured on a monthly basis from April to November and once in February. These data are being analyzed to elucidate any trends in species composition or biomass along the gradient and to identify any species that could be indicators of nutrient enriched conditions or thresholds of nutrient loading that may cause shifts in algal species composition or abundance.

Habitat maps, from aerial photos, will be completed on about 5yr intervals to map the extent of eelgrass, macroalgal beds, and marsh habitat. Aboveground eelgrass biomass may also be monitored.

Data Mining -Species and Habitats of Concern Project

The purpose of this effort was to identify vertebrate monitoring programs conducted by both the National Park Service within the Coastal and Barrier Network parks as well as other agencies, including state, local and non-governmental organizations, in or in close proximity to the parks. The goal was to try and identify those species or groups of species existing in the Network parks that have been noted by scientifically based programs as "good indicators of ecosystem health". By narrowing down the number of possible candidates for species monitoring in the Network, small working groups could be assembled by the Network Technical Steering Committee in the near future to discuss the need for development of a Network species monitoring plan. The Scoping Workshop held in April 2000 did include a species workgroup, but after the workshop, participants felt that little was accomplished due to the lack of information readily available, including knowledge of existing species monitoring programs, and complete park species lists. This lack of information was the basis for this data mining project. The workgroup also found it difficult to discuss "species" in general. Because the group included a number of taxa experts in the fields of herpetology, ornithology, mammalogy, etc…it was difficult for them to direct their discussions in a productive manner.

This project has turned out to be a huge effort in terms of the amount of existing information on species monitoring in the coastal parks and so many large, long-term species monitoring programs and the enormity of their data. At this phase of the Network's monitoring plan, the data and information has been compiled on vertebrate monitoring inside and outside the coastal parks, but is still in draft format. Only one component of this data mining effort has been included below in this Phase I report, Avian species monitoring within the Northeast Coastal and Barrier Network

NATIONAL BIRD CONSERVATION PLANS (BCPS)

The following National Bird Conservation Plans (BCPs) are among several existing and developing planning efforts for bird conservation. BCPs are intended to complement other initiatives such as the North American Waterfowl Management Plan, U.S. Shorebird Conservation Plan, and North American Colonial Waterbird Plan.

Partners In Flight (PIF) Bird Conservation Plans

The goal of PIF landbird conservation planning and the BCPs is to ensure long-term maintenance of healthy populations of native landbirds. The BCPs primarily address nongame landbirds, which have been vastly under-represented in conservation efforts, and many of which are exhibiting significant declines that may be arrested or reversed if appropriate management actions are taken. The PIF approach differs from many existing federal and state-level listing processes in that it (1) is voluntary and nonregulatory, and (2) focuses proactively on relatively common species in areas where conservation actions can be most effective, rather than the frequent local emphasis on rare and peripheral populations. PIF Bird Conservation Plans therefore provide the framework to develop and implement habitat conservation actions on the ground that may prevent the need for future species listings.

PIF Conservation Plans which are applicable to the Northeast Coastal and Barrier Network include:

CACO, FIIS, SAHI, and GATE -Southern New England (Physiographic Area 09) Conservation Plan

Table (??) lists PIF's priority bird species pool for Area 9 and presence/absence of the listed species within the above listed parks;

Maritime Marshes and Beach/dune habitat were the two highest priority habitats listed for this region

Species with highest total scores include:

Salt Marsh Sparrow

Piping Plover

Seaside Sparrow

American Oystercatcher
Black Rail.
Within the maritime marsh habitat Focal species noted included:
Saltmarsh Sharp-tailed Sparrow,
American Black duck
Northern Harrier.
The maritime marsh habitat suite also included nine species of waders.
ASIS, THST, GEWA and COLO-The Mid-Atlantic Coastal Plain (Physiographic Area 44) Conservation Plan
Table (??) lists PIF's priority bird species pool for Area 44 and presence/absence within the parks mentioned above.
Species with highest total scores include the Piping Plover, Roseate Tern, Salt Marsh Sharp-tailed Sparrow, Black Rail, Seaside Sparrow, American Black Duck, King Rail, Wilson's Plover, Clapper Rail and American Oystercatcher
Barrier and Bay Islands and Salt Marshes among the top three highest priority habitats listed for this region
Within the Barrier and Bay Island habitat, a total of 21 bird species were listed which included six species of terns and five species of waders
(PIF contact information can be found at www.PartnersInFlight.org)
NOTE: In association with PIF, the Cornell Laboratory of Ornithology has recently published **A Land Manager's Guide to Improving Habitat for Scarlet Tanagers and other Forest-interior Birds"**. It is the first in a forthcoming series of habitat management guidelines as a tool to help those interested in managing and protecting habitat for birds. These guidelines offer a set of "management prescriptions"—descriptions of the kinds and amounts of habitat that are required to sustain healthy bird populations. It describes the kinds and amounts of forest habitat required to sustain healthy forest bird populations. To download a PDF version of the guidelines go to http://www.birds.cornell.edu/conservation/tanager/.

The North American Waterfowl Management Plan (NAWMP)

The NAWMP is an international action plan involving Canada, the United States and Mexico to conserve migratory birds throughout the continent. The Plan's goal is to return waterfowl populations to their 1970s levels by conserving wetland and upland habitat. The work is accomplished through partnerships called Joint Ventures. Joint ventures are comprised of individuals, corporations, conservation organizations, local, state, provincial and federal agencies. Habitat joint venture actions include protection, restoration and enhancement of wetland and associated upland habitats. The species joint ventures address monitoring and research needs. Current species joint ventures include Black Ducks and Arctic nesting geese.
The goal of the **Atlantic Coast Joint Venture**, which encompasses the Northeast Coastal and Barrier Network, is to "protect and manage priority wetland habitats for migration, wintering, and production of waterfowl, with special consideration to black ducks, and to benefit other wildlife in the joint venture area." The specific objectives are to protect, manage, and enhance 355,787 hectares (879,138 acres) of wetland and upland buffer areas, and to improve and enhance an additional 67,171 hectares (165,977 acres) of federal and state wetland habitats currently managed for waterfowl within the Atlantic Coast Joint Venture Area, to maximize carrying capacity for waterfowl and other wildlife. Estuarine complexes in this region which are extremely important to wintering and migrating waterfowl, including Great Bay (NH), Long Island Sound, Peconic and Great South bays (NY), Delaware Bay, Chesapeake Bay, and embayments created behind barrier beaches. Approximately 65% of the total wintering Black Duck population can be found in coastal areas between Long Island and North Carolina. Exploitation and pollution of Chesapeake Bay and Absecon Bay (NJ), and the accompanying loss of submerged aquatic vegetation, have significantly reduced their value to waterfowl.

North American Waterbird Conservation Plan:
Over the past several years, a Waterbird Monitoring Partnership comprised of non-governmental agencies, researchers, private individuals, academics, and federal and state governmental agencies was established with the goal of developing a continental network of collaborators who agree to and implement comparable population monitoring techniques and a centrally managed waterbird database. This continent-wide waterbird monitoring partnership is being coordinated by the USGS Patuxent Wildlife Research Center's Monitoring Program. A North American Waterbird Conservation Plan (NAWCP) was then developed. An unformatted version of the published Plan (due out August 2002) is now available for review. This version of the plan addresses in detail only those species nesting in colonies. A second version, addressing non-colonial marshbirds will be developed over the next year. The NAWCP call for a set of standardized waterbird monitoring methods to be developed for both population and habitat at multiple geographic and temporal scales. As part of the conservation plan, a manual of recommended standardized breeding season population monitoring methodologies has been produced for use by resource agencies and NGOs, and will be updated as methods are further improved and tested (see below for link). The purpose of the monitoring manual is to provide guidance to individuals developing new waterbird monitoring programs, or interested in improving data comparability(http://www.nacwcp.org/).

Waterbird Conservation Regions applicable to the NPS Coastal Network include:
The New England/Mid Atlantic Region (CACO, FIIS, SAHI, and GATE); and
Southeastern Coastal Plain and Appalachian Mountain (SECPAM) Colonial Conservation Regions (ASIS, GEWA, THST, and COLO).

The following species were identified as candidates for priority species in the SECPAM region. (Species mentioned are applicable to the NPS coastal Parks)
Black-crowned Night Heron, Black Skimmer, Common Tern, Forster's Tern, Greater Shearwater, Gull-billed Tern, Least Tern, Little Blue Heron, Roseate Tern, Royal Tern, Sandwich Tern, and Tricolored Heron.

U.S. Shorebird Conservation Plan
During the past few years, enormous progress has been made in developing national and regional plans for monitoring shorebirds. Shorebirds have been identified as one of four major avian programs under the newly formed North American Bird Conservation Initiative (NABCI). Several dozen shorebird experts have prepared a U.S. Shorebird Conservation Plan. The U.S. Plan includes a proposed national monitoring program. Regional shorebird plans have also been prepared under the auspices of the U.S. Plan, and each of them calls for regional monitoring programs. Thus, a rich infrastructure, almost undreamed of just a decade ago, now exists for developing and implementing shorebird monitoring programs.

The North Atlantic Planning Region is within the Atlantic Flyway, and encompasses all or part of the following states: Virginia (VA), Maryland (MD), Delaware (DE), New Jersey (NJ), Pennsylvania (PA), New York (NY), Connecticut (CT), Rhode Island (RI), Massachusetts (MA), Vermont (VT), New Hampshire (NH), and Maine (ME). The North Atlantic region is extremely important for transient shorebirds during both northbound and southbound migrations. The region is critical for the Western Hemisphere population of Red Knots (*Calidris canutus rufa*), which is extremely concentrated in Delaware Bay each spring. It also supports most of the Atlantic Flyway's breeding Piping Plover (*Charadrius melodus*), a federally threatened species. Shorebirds in this region face potential impacts

from: 1) recreational disturbances to foraging and nesting birds, 2) oil spills, 3) extraction of resources affecting shorebird food supplies (e.g., horseshoe crabs), 4) habitat loss due to development, 5) predators, 6) contaminants, and 7) habitat management that lacks integration with shorebird needs.

Breeding Bird Survey (BBS):
The North American Breeding Bird Survey (BBS), which is coordinated by the National Biological Service and Canadian Wildlife Service, is a primary source of population trend and distribution information for most species of North American birds. NPS Coastal and Barrier Network sites that presently have or have recently had the BBS occurring within their boundaries include:
COLO (1992; 1996-1999)-along Colonial Parkway,
ASIS (1992-present at Chincoteague NWR)
CACO (1989-1999).

BBS are located close to:
THST (1966-present)
FIIS (1966-1972; 1986-1996).
(Data can be located through the website http://www.mp2-pwrc.usgs.gov/bbs)

State Breeding Bird Atlas (BBA):
Birders in Great Britain and Ireland were the first to format methods and complete an Atlas to their breeding birds. The methods involve dividing as area (state, province, country) into uniform "blocks." The blocks are thoroughly surveyed, and observers note the breeding status of all birds in the area. The data is compiled, and the breeding ranges of all species are mapped. Atlases have been completed in the following states: New York (FIIS, GATE, SAHI), New Jersey (GATE-Sandy Hook Unit), and Maryland (ASIS, THST).
The species lists from the 1980-1985 Atlas for FIIS, GATE and SAHI have been downloaded and will be entered into the NPSpecies database. The Atlas database can be accessed at http://www.dec.state.ny.us/website/dfwmr/wildlife/bba/results/index.cfm. Mark Hoffman, the MD Atlas coordinator has been contacted to obtain Maryland Atlas data at ASIS and THST. Data from the Sandy Hook Unit of GATE has been obtained from the NJ Atlas data manager in Excel format and will be entered into NPSpecies. In addition, the Massachusetts Audubon Society is preparing to publish The Massachusetts Breeding Bird Atlas. Bird data maps from the Virginia Breeding Bird Atlas project will be available within a few months. A book will be coming out about the Birds of Virginia that includes the species accounts from the Atlas work as well (pers. communication Larry Lynch, Pres. VA Society of Ornithology). Coordinators of the Atlas are: Richard Banks e-mail: Richard_Banks@USGS.GOV; Roger B Clapp, USGS Patuxent Wildlife Research e-mail Clapp.Roger@NMNH.SI.EDU. In April 2002, Roger Clapp indicated the book may be available in 2003.

Monitoring Avian Productivity and Survivorship (MAPS) program
The Monitoring Avian Productivity and Survivorship (MAPS) program is a cooperative effort among public agencies, private organizations, and individual bird ringers in North America to operate a network of over 500 constant-effort mist netting and ringing stations during the breeding season (DeSante et al. 1995). MAPS was established in 1989 by The Institute for Bird Populations (IBP) and was patterned to a large extent after the British Constant Effort Sites (CES) scheme operated by the British Trust for Ornithology (Baillie et al. 1986, Peach et al. 1996, 1998). MAP programs are occurring at:
CACO
GATE (Ft. Tilden)
Other MAP stations are located close to SAHI and FIIS.

The Christmas Bird Count (CBC):
The CBC began over a century ago in order to determine winter distributions of various bird species. CBC is used to monitor the status of resident and migratory birds across the Western Hemisphere. Volunteer birders of all skill levels from all 50 states, every Canadian province, parts of Central and South America, Bermuda, the West Indies, and Pacific islands count and record every individual bird and bird species seen during one 24-hour calendar day in late December. Count results are available at http://www.audubon.org/bird/cbc.
Historic and current count circles cover all or a portion of the following NPS sites:
CACO, FIIS, GATE, ASIS, COLO, GEWA.
Data is available for historic and current count circles located close to THST and SAHI.

Mid-Winter Aerial Survey Data
Since 1955, state biologists for the entire Atlantic coast have conducted an annual midwinter aerial waterfowl survey. Waterfowl counts are done over all water areas that traditionally have had waterfowl using the habitat including many NPS sites. State biologists usually flying in USFWS planes conduct these surveys. Although, the USFWS maintains the database, they combine data for the whole state and can not usually give data from specific areas. However, it is possible to request data for specific areas several months in advance of the following year's survey, which occurs in January. The state waterfowl biologist for the areas of interest should be contacted to request specific area surveys.

National Wildlife Refuge (NWR) Data:
All waterbirds, including waterfowl, are counted at the refuges every two weeks and at the management area monthly. The counts show the importance of salt marsh habitats to waterfowl year round and the seasonal occurrence of waterfowl species at each refuge. Several of the Coastal Network sites have refuges within their boundaries or adjacent/nearby their boundaries.
ASIS includes Chincoteague NWR
GATE includes Jamaica Bay NWR.
FIIS (William Floyd Estate) is located near (approximately 2 miles) the Wertheim NWR
SAHI is located near Oyster Bay NWR.
CACO Monomoy NWR is located adjacent to the southern end.

Database of Colonial Waterbird Surveys:
This database is made possible by the participation of monitoring partners throughout the Americas, who conduct surveys of waterbirds and voluntarily contribute their data to this centralized location. As of May 2002, this database contains data from the coastal surveys conducted in the mid-1990s from Maine to Georgia, funded by the US Fish and Wildlife Service, in addition to information published in a number of colonial waterbird atlases in the United States and Canada. In the near future, data from the Cornell Waterbird Register and the US Fish and Wildlife Service-sponsored Great Lakes waterbird surveys will become available. Over time, the utility of the database will grow, as partners throughout the Americas contribute data. This data has been obtained and will be entered into NPSpecies and the Dataset Catalog. To access data regarding specific sites within a C&B park go to: http://www.mp2-pwrc.usgs.gov/cwb/.

Breeding Bird Census
The former U.S. Bureau of Biological Survey initiated the concept of a Breeding Bird Census (BBC) in 1914. The Biological Survey initially administered these censuses. Between 1937- 1984, the National Audubon Society sponsored the program and published the annual results in American Birds and its predecessor publications. Since 1985, the Cornell Laboratory of Ornithology has administered the BBC. The results were not published for several years during the 1980s, but have appeared as a

supplement to the Journal of Field Ornithology during the 1990s. For more information about the BBC, instructions for establishing BBC plots and possible use within the C&B parks, or to obtain instructions and data forms, please contact: James D. Lowe,Cornell Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca, New York 14850

Avian Monitoring Programs Existing within the Coastal and Barrier Network Parks

Assateague Island National Seashore (ASIS)

Landbirds/Neotropical Migrants
Breeding Bird Survey (BBS) The BBS is conducted on the Chincoteague NWR end of ASIS lists 76 species of passerines found within its boundaries including Henslow's Sparrow and Sedge wren that are listed on MD DNR as Threatened.
Winter Bird Survey The Winter Bird Survey was developed in Maryland by Danny Bystrak dbystrak@aol.com. The goal of this survey is to create standardized maps of the relative abundance of wintering birds in Maryland using transects. The project was systematically completed over the course of 6 winters, resulting in the publication of both contoured winter distribution maps and atlas style dot maps. The publication has GIF formatted color maps of the winter distribution of each of the species recorded in Maryland. This data is available through MD DNR and has been requested.
Neotropical Migrant Songbird Study The NPS NRBIB lists a neotropical migrant songbird study published by Sarah Mabey in 1993 (ASIS #7728). However, it is unknown if this was a long-term monitoring program. Currently, no long-term monitoring programs for passerines on ASIS are being conducted through the National Park Service (pers. communication, Carl Zimmerman).

Colonial Waterbirds

The following species of colonial waterbirds are found on ASIS and are listed on the State of MD's T&E list: Royal tern (E),Roseate tern (E), Gull-billed tern (T),Least tern (T),Black skimmer (T). Species in Need of Conservation include the American bittern, Least bittern, Black rail and Common moorhen.

A study regarding the status and distribution of Colonial Waterbirds in Virginia noted the barrier island/lagoon system of the Eastern Shore (including Chincoteague NWR) as the most important region for the majority of colonial species encountered. In 1993, this region supported 23 of the 24 colonial species found in coastal Virginia and accounted for >70% and 50% of all breeding pairs and colonies, respectively. For 18 of the 24 species, the region supported >50% of the known coastal population. Also, it was noted that three species included in the 1993 survey have colonized coastal Virginia in the 20 years since the broad surveys of the mid-1970's (Custer and Osborn1977, Erwin and Korschgen 1979). These species include the White Ibis, the Double Crested cormorant and the Brown Pelican. The following species were noted to have declined in coastal Virginia during the last thirty years: Tricolored Herons (coastal population is >50% reduced since mid-1970's); Little Blue herons (drastic decline 1950's-1970's and now found only on seaside of the Eastern Shore); Black-crowned Night Heron (population estimate is 80% reduction since 1975); Gull-billed tern and Black skimmers have dropped to less than 20% to 30% of their population levels in the mid-1970's (Watts and Byrd 1998). No threats to the populations were noted within this study.

Available records since 1976 show that the Maryland portion of ASIS has often supported a breeding population of Least Terns. ASIS provides some of the only natural nesting habitat the species in Maryland. The highest estimated population between 1993 and 2001 was 320 breeding pairs in 1998. As of 2001, the Least Tern breeding population at ASIS was estimated as 92 pairs on the north end and

113 pairs in the ORZ zone. This estimate was determined by an incubation survey conducted by MD DNR staff. Observations indicate productivity is widely variable. Generally, Least Terns arrive late April and nest are active between mid-May through late July.

A long-term monitoring breeding Colonial Waterbird program through the state of Maryland has been conducted since 1985. Currently, ASIS staff collect this data for MD DNR that includes species and breeding population estimates.

Shorebirds

Piping Plover Monitoring Program

ASIS and Chincoteague NWR refuge staff monitor piping plover breeding over the entire breeding season. Monitoring of the Piping plover breeding success has been conducted on ASIS since the species was Federally listed as Threatened in 1986. Since 1985, all known Piping Plover nesting activity within the state of Maryland has been limited to ASIS. Primary management objectives for ASIS in 2001 included monitoring the breeding population, documenting productivity, limiting human disturbance and providing protection from predators. In addition, other beach-nesting bird species are monitored.

Migratory and Resident Shorebirds Monitoring Program

In addition to Piping Plover, ASIS resource management staff collected occurrence records documenting migratory and resident shorebirds as part of long-term monitoring program and between 1984 and 1996. In 1992, fifty-three species of shorebirds were observed using the beach or near-shore habitat. American Oystercatcher nests have been noted since 1993 at ASIS. The majority of the nests are located in the north end although a few nest are located in the ORZ zone.

Waterfowl

Midwinter Aerial Survey and Waterfowl Breeding Surveys conducted by MD DNR-It is currently unknown if waterfowl breeding surveys have been conducted at ASIS by MD DNR. It is currently unknown who the contact person is at MD DNR regarding this waterfowl data.

National Wildlife Refuge (NWR) Data: All waterbirds, including waterfowl, are counted at the refuges every two weeks and at the management area monthly. The counts show the importance of salt marsh habitats to waterfowl year round and the seasonal occurrence of waterfowl species at each refuge. Several of the Coastal Network sites have refuges within their boundaries or adjacent/nearby their boundaries ASIS including Chincoteague NWR Historical waterfowl surveys include Roy Kirkpatrick's et al (Virginia Polytech and State University) 1992 Waterfowl Population Assessment at Assateague Island National Seashore, a Black duck Banding Program was initiated in approximately 1978 and in ? Harvey conducted a waterfowl breeding survey. Kirkpatrick's assessment was a compilation of historic data from available sources providing population trend data from 1979 to 1991 in addition to providing a summary of taxonomy, natural history, and population status of waterfowl species of ASIS. He also conducted monthly aerial surveys to provide temporal and spatial data on waterfowl species at ASIS during winter 1991-92 and provided recommendations for monitoring protocols of waterfowl on ASIS.

Currently, there are no known monitoring programs occurring for waterfowl at ASIS aside from the Midwinter Aerial survey.

Raptors

Peregrine falcon monitoring In 1970, the Department of the Army initiated a program to monitor the tundra peregrine on ASIS and to develop new techniques to assist in the study of highly migratory threatened, endangered and sensitive species. This monitoring program now also includes the American peregrine falcon and has continued on the entire island including Chincoteague NWR for the past 32 autumn migrations.

Midwinter Bald Eagle Survey The Midwinter survey on ASIS has consistently found non-breeding Bald eagles. In 2001, the first breeding pair of Bald eagles was found on ASIS. Two breeding pair are also known to nest in the Virginia portion of Assateague Island.

Northern Saw-whet owl migration and wintering ecology David Brinker who has conducted this long-term monitoring program since 1990 on ASIS focuses on trapping and banding the Northern Saw-whet to document migration movements of saw-whet owls in the northeastern United States. Banding data is compared to other Maryland locations to establish geographic differences in phenology and geographic patterns in age/sex class structure. Other efforts will improve the understanding of how saw-whet owls utilize barrier island habitats during the winter by assessing winter distribution and density.

Recent BBS data (1992-2001) from Chincoteague NWR on Assateague Island lists Osprey, Northern Harrier (1996 only), Red-shouldered Hawk (1993 only) and Red-tailed Hawk, Eastern screech-owl (1999 only), Great Horned Owl and Barred Owl as present. No other known raptor monitoring programs are presently occurring at ASIS

Grassland and Shrubland Birds
No known long-term monitoring program focusing on birds using grassland or shrubland habitats has occurred at ASIS.

Marsh Birds
Aside from the BBA that occurred at Assateague National Seashore, the BBS and CBC occur at Chincoteague NWR at the southern end of Assateague Island. No known marsh bird monitoring programs have occurred at ASIS.

Seabirds
In 1998, The U.S. Fish and Wildlife Service began long-term a study to assess bird mortality in nearshore anchored gillnets in the ocean off New Jersey, Delaware, Maryland, Virginia and North Carolina which included ASIS as one of its' study sites. The study employed four components: Observation of net retrievals; counting dead birds along beaches; aerial surveys for birds and nets; and counting live birds along the shore out to 400 meters offshore. Work on Assateague Island National Seashore involved 8 weekly censuses of the coast from Ocean City Inlet to the south boundary. The data was combined with surveys along 20 other beaches from Cape Hatteras to New Jersey to derive indicators of how gillnets reduce bird populations and for baseline data for future use.

Cape Cod National Seashore (CACO)

Landbirds/Neotropical Migrants

BBS, BBA, Audubon Society In addition to the breeding landbird data collected from the BBS and BBA programs, the Wellfleet Audubon Society is located near to CACO and maintains a year-round bird species list.

Programs, which are involved with, inventory and developing breeding bird monitoring protocols at CACO are the following:

MAPS MAPS at CACO is conducted in three habitats (oak forest, pitch pine forest and pitch pine scrub) and at sites adjacent to low and high residential density to determine population size, annual productivity and inter-annual survival. This project was initiated in 1999 and will continue through 2003.

*Plot Counts*Variable circular plot counts are being used to monitor the distribution, abundance and habitat association of landbirds at CACO. Curtis Griffin, PhD and his students from the University of Massachusetts are conducting this work. This work was initiated in 2001 and will continue through 2002.

CBC, Wellfleet Audubon Wintering landbird data for CACO can be found through the CBC conducted at CACO and the Wellfleet Audubon Society that maintains a year-round bird species list

No known long-term monitoring programs focusing on migratory landbirds is conducted at CACO.

Colonial Waterbirds

A protocol for monitoring colonial waterbirds within the C&B Parks is currently being developed at CACO. Transect counts are being used to estimate number of nesting pairs at waterbird colonies throughout the park.

The following breeding birds are being monitored for nesting sites, # of nests, productivity:
Least Tern: This bird species usually breeds on the supratidal beach habitat. Least terns have similar nesting requirements to piping plovers, but tend to require wider beaches and use larger areas of sparsely vegetated dunes. Colonies of 6 to 1000 have been found in Massachusetts.
Common Terns and Roseate terns both nest on New Island at CACO. Nest searches and counts are conducted. In recent years approximately 1,000 pairs of Common Terns were counted. There appears to be a constant exchange of birds between New Island and Monomoy Island throughout the season and on a yearly basis. In 2001, a total of four pairs of Roseate Terns nested on the southeast corner of New Island; however, no nests successfully fledged chicks. Peter Trull et. al. conducted several studies of Roseate Terns Sterna dougallii around Cape Cod, Massachusetts, during the post-breeding period (July-September) in 1990-1998. Trull noted that keeping pre-migratory staging and roosting areas vehicle free may be the single most important management factor in securing preserved habitats for the endangered roseate tern, as well as the common tern.

Arctic Terns: Three pairs of Arctic Terns have nested on the southwest corner of New Island for 25 years (Trull pers. comm.). Three nests were found in 2001 and monitored throughout the season. However, no Arctic Tern fledglings were ever observed. This site represents the southernmost nesting location of Arctic Terns in the United States.

Black Skimmers: Five pairs of Black Skimmers nested on the sandy interior of New Island. Although a relatively low number, this represents one of only two nesting sites active in the state (the other being Monomoy Island) and the largest colony in the state. It is believed that there was some exchange of pairs between New Island and Monomoy when nests were lost in either location. Only one nest with hatched chicks (three < 1-week-old chicks) was observed. All other nests were lost to unknown causes or never hatched any chicks. No fledglings were ever observed on the island. New Island is the northernmost nesting location of the Black Skimmer in the United States.

Laughing Gulls: The largest Laughing Gull colony in the state is found on New Island. In 2001, their population estimate was 773 pairs. This colony has stayed relatively constant in size for several years.

Piping Plovers: All piping plover field activities were completed by the Seashore's piping plover biological technicians. See their annual report for details. A piping plover nest location map was created from data in this report.

Other Colonial Nesting Waterbirds: One American Oystercatcher pair was recorded at Jeremy Point. A GPS location was taken for their nest. Nine Great Black-backed Gull pairs were recorded at Wood End/Long Point, and one pair was also observed at New Island. Seventy-five Herring Gull pairs and three Black-crowned Night-heron pairs were also recorded at Wood End/Long Point.

Inventory and monitoring activities for migrating and wintering waterbirds include fixed site foraging surveys, foraging survey routes, roosting survey routes, and aerial surveys. All aerial surveys were contracted out and performed by Peter Trull.

Shorebirds

Piping Plover Monitoring Program At CACO, Piping plover nests increased from fifteen to twenty in one year in the late 1980's to from 60 to 110 per year in the 1990's.

Protocol for Shorebird Monitoring Currently, Michael Erwin and Robert Cook are developing a protocol for shorebird monitoring. The distribution, abundance and species composition of flocks of waterbirds including sandpipers and plovers is monitored over the course of the fall migration (July to November) at selected sites in the park. Sites are partitioned into smaller areas and all birds counted. Counts are conducted at low and high tide.

Wellfleet Audubon Society Shorebird Monitoring Program In addition to this work, the Wellfleet Audubon Society monitors shorebirds at Wellfleet Harbor including Great Beach and Great Island.

Species Composition and Migration Chronology Study An historical study of shorebirds at CACO includes Jennifer Brown's 1994 master's thesis on species composition, migration chronology.

Waterfowl

Massachusetts Division of Wildlife (MassWildlife**)** Mid-winter Waterfowl Survey: It takes 3 to 4 days to fly Massachusetts' 2,200 miles of coastline, which includes CACO. Normally two planes are used to take maximum advantage of the brief periods of good weather in early January. Results are usually tabulated by the middle of the month for Massachusetts, but figures for the entire flyway are not available until late February. For more information call H. Heusmann (508) 792-7270. MassWildlife cooperates in other joint surveys with the US Fish and Wildlife Service and with biologists from other state fish and wildlife agencies. As part of the cooperative interstate effort to manage waterfowl, the Division heads up the northeastern waterfowl breeding survey, engages in summer banding efforts, and participates in the Atlantic Flyway Council meetings. At this time, it is unknown if any of this work is being performed at CACO.

National Wildlife Refuge Data: All waterbirds, including waterfowl, are counted at the refuges every two weeks and at the management area monthly. The counts show the importance of salt marsh

habitats to waterfowl year round and the seasonal occurrence of waterfowl species at each refuge. Monomoy NWR is located adjacent to the southern end of CACO.

Raptors

In a mid-1990's, a survey of grassland/heathland birds was conducted at CACO. A repeat of this survey was conducted in 2000. While not quantified, the Massachusetts Threatened Northern Harrier (*Circus cyaneus*) was frequently observed and nesting confirmed.

Pilgrim Heights Hawk Watch The Massachusetts Audubon Society's Wellfleet Bay Wildlife Sanctuary, in partnership with Eastern Massachusetts Hawk Watch, conducts an annual spring hawk watch on Pilgrim Heights at CACO. The data will be used monitor hawk species and their abundance. This project began in 1998 although counts have occurred at Pilgrim Heights and at other locations on the Outer Cape in the past.

Data from the BBS 1989-1999 at CACO list Northern Harrier (1990 only); Red-tailed Hawk (1996 only) and the American kestrel (1995 only) as present.

Grassland Birds

The remaining significant grassland habitat in Massachusetts is found mainly in the Connecticut River Valley and the coastal sandplains of Cape Cod including CACO(Shriver et al. 1997, Jones and Vickery 1997). Based on the statewide surveys conducted from 1993 to 1995, Cape Cod, with its expanses of heathlands and coastal sandplains, emerges as important in the regional survival of grassland nesting birds.

Grasshopper sparrows are rare and local nesters on the Cape, confirmed only at the Crane Wildlife Management Area in Falmouth, and Otis Air Force Base (Veit and Petersen 1993). However, in 1963, at least 10 pairs nested at Fort Hill, with scattered pairs in Truro and Wellfleet (Bailey 1968). In 1965 their distribution was recorded in suitable habitat over the entire Cape out to North Truro, although numbers indicated decline since the 1930's (Hill 1965). Breeding Grasshopper Sparrows were not recorded in a 1993-1995 state survey at CACO or in a repeat survey in 2000 at CACO. It is now thought that they may be extirpated from the park. However, it is noted that Grasshopper Sparrows are secretive birds with a cryptic call that could be easily overlooked (Bailey 1968, Bent 1968, Forbush 1929). The habitat of these sparrows is also transitory, and loose colonies of the birds tend to appear and disappear abruptly (Veit and Petersen 1993, Bailey 1968).

During the 1993-1995 statewide survey, Vesper Sparrows were found to be widely distributed, but in small numbers across the state (Jones and Vickery 1997). Vesper Sparrows are also rare and local nesters on Cape Cod (Veit and Petersen 1993). In 1965 they were recorded as scattered pairs of about 20 in Chatham-Orleans and 20-25 in North Truro, but they had been decreasing in numbers since the 1930's, paralleling the eastward extension of the forest (Hill 1965). In the 1993-1995 survey, CACO was found to have significant nesting habitat for these birds, accounting for 25% (34 of 132) of all Vesper Sparrows recorded statewide. Important areas were the sand dunes that run from Provincetown to Truro, Provincetown Airport, Marconi Barrens in Wellfleet, and Griffin's Island in Wellfleet (Massachusetts Audubon Society 1995, Jones and Vickery 1997). A repeat of this survey was conducted in 2000 at CACO. Whereas 34 singing males were recorded from four sites in the mid-1990's, a total of 17 were recorded from two sites in 2000. Of the coastal grassland /heathland habitat in Cape Cod National Seashore, 450 ha (62%) of heathland have disappeared between 1962-1985 (Carlson et al. 1992). This loss of habitat seems to be increasing in rate due to the encroachment of

pitch pine and scrub oak. Management options suggested by Carlson et al. (1992) include no action, burning, mowing, clipping followed by herbicide treatment, and grazing. "No action" is the management option that has led to the observed succession from heathland to forest over the past 30 years. Heathlands are relatively rare in the United States, and are mentioned in the General Management Plan for Cape Cod National Seashore as important plant communities to be preserved (NPS 1996).

Marsh Birds

A salt marsh and grassland monitoring study was recently conducted by the Massachusetts Audubon Society and included 10 sites at CACO. This study confirmed the presence of seven, of the targeted eleven, marsh bird species (American Bittern, American Coot, King Rail, Least Bittern, Pied-billed Grebe, Sora, and Virginia Rail) at CACO. Six of these were documented from calls elicited by tape playback, the other, the American Coot, was identified visually. The most commonly detected marsh birds were Sora (n=15), Pied-billed Grebe (n=13), and Virginia Rail (n=12). Great Pond, Provincetown (n=22) and Hatches Harbor Inside Dike (n=15) were the most common locations.

Additionally, records were kept of other species that use CACO wetlands and are under-sampled by other monitoring programs. Thirteen of these "secondary" species were recorded at nine of the eleven monitoring wetlands. Common Yellowthroats (n=167) were by far the most commonly recorded, with Marsh Wrens (n=23), Belted Kingfishers (n=16), Northern Harriers (n=6), and several species of waterfowl also recorded.

Further, freshwater/brackish wetlands held 54 of the 57 target species records

Colonial National Historical Park (COLO)

Landbirds/Neotropical Migrants

BBS It is important to note that the most recent Breeding Bird Surveys (approximately 1992-present) at COLO have been conducted by Dana Bradshaw of The Center for Conservation Biology at the College of William and Mary. His work is a continuation of surveys that have been conducted since 1966 along the Colonial Parkway between Yorktown and Jamestown Island. An average of about 65 species were recorded annually over the past several year. New additions to the survey include the Bald Eagle and Double-crested cormorant in 1999. Also that year, it was noted that the prairie warbler and Kentucky warbler were absent relative to previous surveys.

No known long-term monitoring programs focusing on migratory landbirds is conducted at COLO.

Colonial Waterbirds

COLO provides nesting habitat for great blue herons, great egrets and least bitterns. These species are listed by the Virginia Natural Heritage Program. Although Great blue herons are frequently encountered in the wetlands of eastern Virginia, the species habitat is limited and threatened by development pressures. Additionally, the species colonial nesting habits puts individuals at risk to single disturbances. Great egrets are near the northern edge of their range in Virginia where they are migratory, although scattered individuals can be found in southeast Virginia and the Eastern shore year-round. Great egrets are considered very rare in Virginia as a breeding species because they are known from only approximately ten colonies in five counties. There are only thirteen known least bittern breeding sites in just eight counties of Virginia; therefore, this species is considered very rare. In the Jamestown Island Natural Area of COLO, there is a population of least bitterns occupying the

herbaceous wetlands. There were estimated to be over thirty individuals living in these wetlands around Passmore Creek during a survey in July, 1991.

In its management plan for COLO, the state of Virginia's Division of Natural Heritage notes: Great blue herons and great egrets nest in one of the largest heron nesting colonies in Virginia along Beaverdam Creek. The colony supports up to 500 pair of these two species. An aerial survey over the colony by VDIF observed 405 great blue heron pairs and 65 great egret pairs in the spring of 1994. Also, great blue heron colonies are located on Jamestown Island and Swann's Point in COLO. It is noted that great egrets may also be nesting in these colonies. One hundred fifty-five nesting pairs of great blue herons were documented at Jamestown Island and ninety nesting pairs were documented at Swann's Point during a 1994 aerial survey by VDGIF and the College of William and Mary.

The principal threat to the least bittern population in the Jamestown Island Natural Area is alteration, destruction of their herbaceous wetland habitat or a substantial increase in visitation to the herbaceous wetlands around Passmore Creek. Least bitterns are difficult to monitor quantitatively because of their secretive behavior. It was noted that the herbaceous wetlands of Passmore Creek and its tributaries should be surveyed for least bitterns annually every July. Active searches from a small boat or canoe and passive searches from a blind or secluded location should be conducted. The observer should note numbers and locations of least bitterns seen and heard as well as any evidence of nesting activity observed.

Habitat conservation zones have been established for this nesting colony as well as conservation zones for some foraging habitat. In the recent past, the heron and egret nesting colony were monitored every three years by VDGIF. The number of nesting pairs, location and extent of the colony were recorded on aerial surveys in early spring.

A study regarding the status and distribution of Colonial Waterbirds in Virginia noted the western shore (includes COLO) and the south side regions were most significant for supporting a large number of great blue heron and great egret colonies. Breeding of the coastal population of double-crested cormorant populations have increased rapidly since first confirmed in 1978. As of 1996, five colonies had been located in coastal Virginia.

In addition to VGIF's surveys of great heron/great egret colonies an annual BBS is conducted along Colonial Parkway.

Shorebirds

Although COLO habitats include 37 miles of shoreline (34 acres), 2482 acres of wetlands, 3061 acres of floodplain, it does not support large numbers of shorebirds primarily due to its' predominance of emergent wetland. There are no accounts of breeding shorebirds at COLO. In addition, there are no documented records of COLO being a site that supports large numbers of migratory shorebirds. However, one species list for COLO notes 14 species of shorebirds in the park.

Waterfowl

The Chesapeake Bay Coastal Program is working with other federal, state and local agencies to protect living resources. Under a Memorandum of Agreement with the Environmental Protection Agency, the U.S. Fish and Wildlife Service is a major partner in the Chesapeake Bay Program, a multi-agency effort to restore living resources and water quality of the Chesapeake Bay. Through its

participation, the Service has facilitated a number of important activities such as: Completed a comprehensive survey of all Chesapeake Bay waterbirds; Conducted a 40-year waterfowl status and trends study; Coordinated Chesapeake Bay wetlands status and trends survey; Coordinated development of a Chesapeake Bay habitat restoration strategy and restored thousands of acres of wetlands and other important fish and wildlife habitats throughout the Chesapeake Bay watershed.

Raptors

Currently, Bald Eagle nests at COLO are monitored using aerial surveys in March and then one more time in the nesting season to determine survivorship of the nestlings. Mitchell Byrd and Bryan Watts at the College of William and Mary's Center are completing this work for Conservation Biology.

Recent data from the COLO Parkway BBS lists Osprey, Red-shouldered Hawk and Red-tailed Hawks as present. No other known raptor monitoring programs is presently occurring at COLO.

Grassland and Shrubland Birds

Bryan Watts of the Center for Conservation Biology at the College of William and Mary wrote Management of Park Fields to Enhance the Natural Resource Value and Diversity of Colonial National Park (Watts, 2001). The following are excerpts from that manual. COLO currently supports 177 patches of open habitat that cover 378.9 ha (935.9 acres) of land. These patches vary in size from very small fragments that cover less than one tenth of 1 ha to larger patches more than 30 ha (74 acres) in area. The majority (76.8%) of patches are less than 2 ha (5 acres) in size. Most of these smaller patches are positioned along roadways and have a very linear shape. A portion of these open habitat patches found within COLO have the potential to support populations of species that are of conservation concern within the mid-Atlantic region. Under the current management regime, open lands do not provide the habitat conditions required by species of conservation concern. A shift from the current to recommended management regime would provide a sustainable source of habitat capable of supporting an estimated 1,453 breeding pairs of open-habitat bird species. This management shift would result in estimated savings in maintenance costs of more than $250,000 over a ten-year period.

No known long-term monitoring program focusing on birds using grassland or shrubland habitats has occurred at COLO.

Marsh Birds

The BBS is conducted annually in COLO along Colonial Parkway and data maps from the VA Breeding Birds Atlas may be available within a few months. In addition, CBCs are conducted annually.

No known long-term monitoring program focusing on birds using marsh habitats has occurred at COLO.

George Washington Birthplace National Monument

Landbirds/Neotropical Migrants

Very little monitoring has occurred within this site aside from the recent CBC (wintering) and possibly BBA (breeding) work.

Annual CBC's have been conducted since 1994 at GEWA.

Colonial Waterbirds

A study regarding the status and distribution of Colonial Waterbirds in Virginia noted the western shore (includes GEWA) and the southside regions were most significant for supporting a large number of great blue heron and great egret colonies. Breeding of the coastal population of double-crested cormorant populations have increased rapidly since first confirmed in 1978. As of 1996, five colonies had been located in coastal Virginia.

Currently, no long-term monitoring programs focusing on colonial waterbirds are being conducted at GEWA through the National Park Service (pers. communication, Rijk Morawe).

Shorebirds
There are no accounts of breeding shorebirds at GEWA. In addition, there are no documented records of any large numbers of migratory shorebirds due to the park's location and lack of appropriate habitat.

Waterfowl
No information.

Raptors

Bald Eagle nesting success and eagle abundance A monitoring program for nesting success and eagle abundance is conducted at GEWA. As of spring 2002, two active nests were located at GEWA. Nature Bib also lists a monitoring program for nesting activity of Bald Eagles from 1977 through 1995 at GEWA.

CBC Species listed on the CBC's from 1936-1941 include the Bald eagle, Turkey Vulture, sharp-shinned hawk and Cooper's Hawk. No other raptor inventories or monitoring programs have been conducted at GEWA.

Grassland and Shrubland Birds

No monitoring programs for grassland or shrubland species have ever occurred at GEWA. Considering the extent of open grasslands and their predominance as a habitat a GEWA, and the extent of marshes, it appears that an initial inventory of grassland bird species is warranted to determine the need for a long-term monitoring program.

Thomas Stone National Historic Site

Landbirds/Neotropical Migrants

Contact with the BBA and BBS coordinators has been attempted to determine if data within THST has been collected. No long-term passerine monitoring programs initiated by NPS have been known to occur at THST.

Colonial Waterbirds

BBA The Maryland BBA data may be the only long-term monitoring program recorded breeding colonial waterbirds within THST boundaries.

CBC The Port Tobacco CBC data may be the only long-term monitoring programs that recorded wintering colonial waterbirds within THST boundaries.

Currently, no long-term monitoring programs focusing on colonial waterbirds are being conducted at THST

Shorebirds

There are no accounts of breeding shorebirds at THST. In addition, there are no documented records of any large numbers of migratory shorebirds due to the park's location and lack of appropriate habitat.

Waterfowl

Waterfowl Breeding Surveys conducted by MD DNR-It is currently unknown if waterfowl breeding surveys have been conducted at THST by MD DNR.

Raptors

BBS data (1966-2001) from LaPlata, Maryland located near THST lists Red-shouldered Hawk, Red-tailed Hawk, Cooper's hawk (1969 only), Broad-winged Hawk, American kestrel, Eastern screech-owl (1982 only), Great Horned Owl (1997 only) and Barred Owl as present.

A CBC completed in 1959 at Port Tobacco, Maryland where THST is located listed Black and Turkey Vultures, Sharp-shinned Hawk, red-shouldered Hawk, peregrine falcon, Great-horned Owl and Barred Owl as present. Other CBC's completed in 1979 and 1987-1994 do not list these species.

Grassland and Shrubland Birds

No monitoring programs for grassland birds species have ever been conducted at THST. Habitats include approximately 20 ha of fields.

Marsh Birds

No monitoring programs for marsh birds species has ever been conducted at THST. Habitats may include some freshwater marsh near the Hog Run stream.

Fire Island National Seashore (FIIS)

Landbirds/Neotropical Migrants

In addition to the BBA, a MAPS program is conducted at East Islip, which is located on Long Island across Great South Bay from FIIS.

CBC, CBC's were completed historically on FIIS from 1963-1971 and on the Atlantic Ocean offshore of FIIS from 1944-1975. Currently, the Captree CBC includes the western end of FIIS. It has been conducted yearly since 1972. It is important to note that this data may include land outside of FIIS boundaries.

Mist-netting at Lighthouse Tract on FIIS Previous research relating to passerines includes mist-netting conducted by P.A. and F. Buckley between 1969-1972 at the undeveloped Lighthouse Tract on FIIS. Bird species and abundance was recorded. This data is unpublished at this time. A follow-up study (1998-2001) was recently completed by P.A. and F. Buckley**.** Bird species richness and abundance will be compared to the prior study. Land bird species from these studies have been entered into NPSpecies from a bird species list compiled by Shoai Mitra and John Putnam.
Neotropical Migrant Point Counts in the Federal Wilderness Area During the summer of 2001, neotropical migrant point counts (10 points with three visits) were conducted in the Federal Wilderness Area by Ernie Taylor, FIIS Resource Manager. The intent of the project was to continue monitoring these points on a yearly basis. The project has been set up for repetition since a GPS layer is being generated for the point count locations.

No current or historical passerine monitoring programs are known to have occurred at the William Floyd Estate.

Colonial Waterbirds

Suffolk County Piping plover/Least tern Protection Program The Suffolk County Department of Parks, Recreation and Conservation manages a comprehensive Piping plover/Least tern Protection Program for thirteen parks throughout the county including Smith Point County Park which lies within FIIS boundaries. Least terns nest on the sandy beaches of the barrier beach complex to the west of Moriches Inlet at Fire Island East (Smith Point County Park). In 1995, 235 pairs of least tern on this stretch of beach were documented. In 2001, only nine pairs of least tern were reported by the Suffolk Count Department of Parks at this site. An annual report is issued for this data and the data is given to the NYDEC for inclusion in its annual report.

NYDEC Colonial Waterbird Survey New York State DEC (NYDEC) has surveyed colonial waterbirds, terns and piping plovers on Long Island using ground counts annually since 1983. The 1998 NYDEC LI Colonial Waterbird and Piping Plover Survey recorded 21 species of nesting colonial waterbirds (GATE and FIIS Sites surveyed) and over 45,000 nesting pairs. Common terns, cormorants, herring, great black-backed and laughing gulls, and least terns are the most common nesting waterbirds listed (>2000 pairs per species). Great egret, black-crowned night heron, glossy ibis, and snowy egret are the most common species of long-legged waders nesting in the New York City area (>500 pairs per species).

In it's 1997 Significant Habitats and Habitat Complexes of the New York Bight Watershed report, the USFWS notes populations of long-legged waders have been fairly stable over the past two decades, although recent declines in snowy egret (50% decline since 1989) and cattle egret (*Bubulcus ibis*) (70% decline since 1989) are of concern. Double-crested cormorants (*Phalacrocorax auritus*) have recovered from earlier declines attributed to DDT and other pesticides and are expanding their range from the north, occupying habitat similar to that of herons and in some instances displacing them.

Harbor Herons Project The New York City Audubon Society has conducted the Harbor Herons Project regularly since 1984. Four islands managed by the NPS have been included in this survey since approximately 1991. These islands include Carnasie Pol and Ruffle Bar in Jamaica Bay and

Swinburne and Hoffman Islands in the waters off Staten Island. As of 2002, other parts of Jamaica Bay will also be surveyed (pers. communication , Todd Fiorentino, NYC Audubon Society Executive Director).

P.A. and F.G. Buckley Colonial Waterbird Studies P.A. and F.G. Buckley, 1980, conducted a monitoring project regarding population and colony-site trends of Long Island for five years in the mid-1970s.

Rutgers University Colonial Waterbird Monitoring Program A colonial waterbird monitoring program was conducted by Rutgers University between 1971 and 1990. All colonies in NJ and selected colonies on western LI (GATE-Sandy Hook Unit and Breezy Point) were ground surveyed.

J. Burger's Colonial Waterbird Studies In addition, J. Burger at Rutgers University monitored Avian Use Patterns of shorebirds, waterbirds, Common Terns and waterfowl between 1978 and 1983. This work was published in the Jamaica Bay Studies I-VIII.

Laughing Gull and Double-crested Cormorant Studies Also important to note, are several Laughing Gull and Double-crested cormorant studies conducted between 1978 and 1986. Although these were studies and not long-term monitoring programs, population estimates were noted in many of the studies

Shorebirds

Seven shorebird species nest within the New York Bight watershed, including beach-nesting shorebirds and grassland-nesting species. These seven species include Piping plover, Killdeer, American oystercatcher, Willet, Spotted sandpiper, Upland sandpiper, American woodcock. In contrast to the clumped distribution of gulls, terns, and long-legged waders, beach-nesting birds are more evenly dispersed along the ocean shorelines of Long Island and New Jersey.

NYDEC Breeding Colonies Monitoring Program Survey groups from the New York State Department of Environmental Conservation, the Nature Conservancy, the Audubon Society and a network of concerned volunteers annually census the breeding colonies on Long Island. With the cooperation of private and public landowners, fencing and signs prohibiting entry have been erected to protect existing colonies from disturbance. Tern/plover stewards actively patrol and monitor nesting sites to increase nesting success and alert the public to the vulnerability of these species to human disturbance. The largest numbers of Piping Plover nest on sand barrier beaches and spits near inlets. The beaches of the New York area supported about a quarter of the total United States Atlantic coast population of piping plover in 1995.

There are 30 species of documented migratory shorebirds, plovers, sandpipers, avocets, and oystercatchers, that regularly use marine and freshwater habitats and adjacent uplands in the South Shore Reserve which is located along southern Long Island, New York for breeding, wintering, northward (spring) migration, or southward (autumn) migration. Analyses of ISS data, Christmas bird counts, and migration season accounts from *American Birds* for the Western Hemisphere Shorebird Reserve Network (WHSRN) identified Jamaica Bay (autumn and spring migrations) as a site with counts of 5,000 or more shorebirds (Table JB Shorebirds). There are also important shorebird concentration areas along the south shore of Long Island (i.e. FIIS) and other bays in New Jersey (i.e. Sandy Hook Bay) that appear to be under-represented in the ISS database and may have similar levels of shorebird use.

Piping Plover On Fire Island, adult Piping plovers forage on the ocean and bay beaches, in overwash areas, swale areas with sparse vegetation, and in vernal pool habitats. The primary habitat for breeding is along wide ocean beaches and overwash areas. Due to its rarity, available data identified only two to four nests per year in the late 1980's, with the numbers declining in the 1990's. Fire Island seems to be

experiencing a rise in predators, and it is feared that the plovers' defense mechanisms may not be as effective when more predators are present.
Carters Island supported the largest number of least terns on Long Island in 1995 (516 pairs). West Inlet Island's (western tip within FIIS boundaries) extensive tidal mudflats are a rich feeding ground for thousands of migratory shorebirds, especially in the fall; shorebirds using these mudflats include whimbrel (*Numenius phaeopus*), sanderling (*Calidris alba*), dowitcher (*Limnodromus* spp.), and several species of sandpipers and plovers, including piping plover. The flats also provide foraging habitat for sanderlings during the winter.
Piping plover and least tern nest on the sandy beaches of the barrier beach complex to the west of Moriches Inlet at Fire Island East (Smith Point County Park). This is one of the more important stretches of beach for these two species along Long Island's south shore. In 1995 there were 34 pairs of piping plovers on this stretch of beach.
The Suffolk County Department of Parks, Recreation and Conservation manages a comprehensive Piping plover/Least tern Protection Program for thirteen parks throughout the county including Smith Point County Park. The program was initiated in 1998. In 1998, four nesting Piping Plover pairs and three fledglings were reported; seven nesting pairs with three fledglings were reported in 2000 and six nesting pairs with nine fledglings were reported in 2001. It is noted that there is extensive erosion that has appeared to reduce suitable nesting areas and a significant predation problem caused by foxes at this site. It was recommended that that predator control and increased monitoring occur at this site. An annual report is issued for this data and the data is given to the NYDEC for inclusion in its annual report.
Both NY and NJ survey certain beach-nesting birds (piping plover and least tern) annually. The Long Island Colonial Waterbird and Piping Plover Survey is an annual survey since 1983. It is a cooperative effort of the NYDEC, The Nature Conservancy, U.S. Fish and Wildlife Service, Audubon chapters. Annual reports are produced and distributed by NYSDEC. NPS staff assist with gathering data at FIIS.

Waterfowl

The South Shore Estuary Reserve (SSER) Waterfowl Draft Technical Report notes that for 1970-1996, the average total waterfowl count for all segments within the SSER was more than 42 thousand birds and the maximum more than 82 thousand birds. Four species accounted for more than 86 percent of total species: scaup (greater and lesser scaup not differentiated), brant, American black duck and Canada geese. Great South Bay had the highest average total counts primarily due to high numbers of scaup (6,563 average). On a per area basis, Fire Island had the second largest number of birds counted per acre.

Fourteen waterfowl species are known to nest and breed in the south shore estuary where FIIS is located. A breeding data summary from the 1980-1985 New York State Breeding Bird Atlas notes Mallard, Canada goose, American Black Duck and gadwall are the most prevalent on Fire Island. Several species such as green winged teal and American wigeon are at the southern end of their breeding range and are sparse and occasional breeders in this area. Other species that rarely breed on Long Island include the red-breasted merganser and ruddy duck, (Andrle and Carroll 1988), The Pied-billed grebe is ?listed as a state threatened species, breeds at Wertheim National wildlife Refuge located nearby the Wm Floyd Estate and is recorded as a probable breeder in other Breeding Bird Atlas blocks in the SSER including FIIS.

The Captree and Central Suffolk Christmas Bird Counts (CBC's) are conducted partially within FIIS lands. These counts and two other counts (southern Nassau County and Quoque-Watermill) in the South Shore Estuary Reserve were initiated in 1966.

In addition to the BBA and CBC, which may have included other areas outside of park boundaries, the following monitoring programs for waterfowl have been conducted at either FIIS, GATE or both parks:

USFWS Waterfowl Surveys of the 1960's-extensive ground and aerial waterfowl surveys were conducted in the Great South Bay and Moriches Bay (including FIIS) in the 1960's for the U.S. Army Corps of Engineers as part of the Fire Island Cooperative Beach Erosion Control and Hurricane Protection Project (USFWS 1965, 1969a, and 1969b**.**

Mid-Winter Aerial Survey Data Along the south shore of Long Island, New York's DEC makes these surveys from fixed wing aircraft.

New York Federated Bird Clubs Winter Waterfowl Counts The Federation of New York State Bird Clubs has conducted annual waterfowl ground surveys from 1955 (1968-1972 no data)-present. Ground counts are conducted in January and the results are reported in the journal *Kingbird.* These counts are useful for determining statewide or regional status or trends. These counts are reported only on a large regional basis, e.g., total number of a species counted in the Long Island/New York City Region and survey areas may change from year to year; therefore, they are not usually useful for determining waterfowl status and trends in particular parks or adjacent areas. However, Don Reipe, NPS biologist stationed at JBNWR, has gathered data for wintering waterfowl specifically in Jamaica Bay over the last several years for NYFBC.

National Wildlife Refuge (NWR) Data: The Wm Floyd Estate, which is part of FIIS, is located near (approximately 2 miles) the Wertheim NWR.

Comprehensive Monitoring Study at Wm. Floyd Estate: Currently, a cooperative effort with USGS/USFWS/Moriches Bay Audubon Society at the Wm. Floyd Estate is underway to conduct annual surveys which includes water tables, salinity levels, vegetation characteristics, invertebrate surveys including mosquitoes, waterfowl surveys and fish surveys. Data collection began in the fall of 1999.

Waterfowl Counts at Wm. Floyd Estate: Listed in NatureBib, waterfowl counts were conducted from 1982-1994 at the Wm. Floyd Estate.

Raptors

There is limited data on breeding and wintering raptor species at FIIS; however, the beach in the Wilderness Area and south of Old Inlet is important for wintering northern harrier, which are possible breeders, short-eared owl, and snowy owl (*Nyctea scandiaca*), all of which forage over swales and the extensive salt marshes fringing the barrier island on its northern edge. Also, data from the BBS 1966-1996 at Jones Beach on FIIS list Osprey (1990 only) and the eastern screech-owl (1996 only) as present. The American kestrel was noted as present in 1966 and 1969.

FIIS Lighthouse Hawk Watch A hawk watch and count at the lighthouse on Fire Island averages over 9,000 raptors during the autumn migration. The most abundant raptors counted, in declining order of abundance, are American kestrel (*Falco sparvarius*), merlin, sharp-shinned hawk (*Accipiter striatus*), northern harrier, osprey, peregrine falcon, and Cooper's hawk (*Accipiter cooperii*).

FIIS Lighthouse Hawk Banding Station Also, a hawk banding station located near FIIS lighthouse administered by Theodore Roosevelt Sanctuary has been conducted in the recent past. Contact with the research director revealed that this trapping station was not productive.

Grassland and Shrubland Birds

No known long-term monitoring program focusing on birds using grassland or shrubland habitats has occurred at FIIS

Marsh Birds

No known long-term monitoring program focusing on birds using marsh habitats has occurred at FIIS

West Inlet Island: Seaside and sharp-tailed sparrows (*Ammodramus maritimus* and *A. caudacutus*), clapper rail (*Rallus longirostris*), and green-backed heron (*Butorides striatus*) nest in adjacent salt marshes.

The upland community of the William Floyd Estate provides habitat for breeding American woodcock (*Scolopax minor*) and a variety of migrating and nesting songbirds, while adjacent tidal areas afford habitat for nesting American bittern (*Botarus lentiginosus*), seaside sparrow, and osprey. This area is one of the few remaining sites on the south shore of Long Island where tidal wetlands are contiguous with an undeveloped upland buffer.

Seabirds
No known long-term monitoring program focusing on seabirds occurs at FIIS.

Gateway National Recreation Area (GATE)
Landbirds/Neotropical Migrants

BBA Data from the New York BBA has been obtained and will be entered into NPSpecies and the Metadata Catalog. Once data from NJ's BBA is obtained for Sandy Hook, it will also be entered into NPSpecies.

MAPS at Fort Tilden Data from this project has been requested from The Institute for Bird Populations data manager and will be entered into NPSpecies and the Metadata catalog when obtained.

Breeding Birds at Floyd Bennett Field: Known historical breeding landbird monitoring programs at GATE include Lent and Litwin's Bird-Habitat Relationships as a Guide to Ecologically-Based Management at Floyd Bennett Field. Part I was a baseline study that included a "summer" bird species list, habitat cover types by area and % of total area conducted in 1984. Part II was a post management evaluation that included a "summer" bird species list (1984-1987), herbaceous plant species list and woody plant species list (1984-1987).

In addition, a paper on the Breeding Birds of Sandy Hook by Wade Wander may have been a long-term monitoring program.

No other known long-term wintering or migratory landbird monitoring programs have recently been completed or are currently being conducted at GATE.

Colonial Waterbirds

NYDEC Colonial Waterbird Survey New York State DEC (NYDEC) has surveyed colonial waterbirds, terns and piping plovers on Long Island using ground counts annually since 1983. The 1998 NYDEC LI Colonial Waterbird and Piping Plover Survey recorded 21 species of nesting colonial waterbirds (GATE and FIIS Sites surveyed) and over 45,000 nesting pairs. Common terns, cormorants, herring, great black-backed and laughing gulls, and least terns are the most common nesting waterbirds listed (>2000 pairs per species). Great egret, black-crowned night heron, glossy ibis, and snowy egret are the most common species of long-legged waders nesting in the New York City area (>500 pairs per species).

In it's 1997 Significant Habitats and Habitat Complexes of the New York Bight Watershed report, the USFWS notes populations of long-legged waders have been fairly stable over the past two decades, although recent declines in snowy egret (50% decline since 1989) and cattle egret (*Bubulcus ibis*) (70% decline since 1989) are of concern. Double-crested cormorants (*Phalacrocorax auritus*) have recovered from earlier declines attributed to DDT and other pesticides and are expanding their range from the north, occupying habitat similar to that of herons and in some instances displacing them.

Harbor Herons Project The New York City Audubon Society has conducted the Harbor Herons Project regularly since 1984. Four islands managed by the NPS have been included in this survey since approximately 1991. These islands include Carnasie Pol and Ruffle Bar in Jamaica Bay and Swinburne and Hoffman Islands in the waters off Staten Island. As of 2002, other parts of Jamaica Bay will also be surveyed (pers. communication , Todd Fiorentino, NYC Audubon Society Executive Director).

P.A. and F.G. Buckley Colonial Waterbird Studies P.A. and F.G. Buckley, 1980, conducted a monitoring project regarding population and colony-site trends of Long Island for five years in the mid-1970s.

Rutgers University Colonial Waterbird Monitoring Program A colonial waterbird monitoring program was conducted by Rutgers University between 1971 and 1990. All colonies in NJ and selected colonies on western LI (GATE-Sandy Hook Unit and Breezy Point) were ground surveyed.

J. Burger's Colonial Waterbird Studies In addition, J. Burger at Rutgers University monitored Avian Use Patterns of shorebirds, waterbirds, Common Terns and waterfowl between 1978 and 1983. This work was published in the Jamaica Bay Studies I-VIII.

Laughing Gull and Double-crested Cormorant Studies Also important to note, are several Laughing Gull and Double-crested cormorant studies conducted between 1978 and 1986. Although these were studies and not long-term monitoring programs, population estimates were noted in many of the studies

Shorebirds

Avian Use Patterns of shorebirds, waterbirds, Common Terns and waterfowl were monitored between 1978 and 1983 by J. Burger at Rutgers University. This work was published in the Jamaica Bay Studies I-VIII. The fall shorebird migration was monitored at JBWR by NPS staff (Thomas Davis and Arthur Morris) from 1981 until 1988. Also, the NPS NRBIB lists a shorebird breeding success program conducted at Sandy Hook from 1985-1988 conducted by Jeanne Hickman-McArthur. In

addition, Brian Harrington at Manomet Center for Conservation Sciences monitored shorebirds at GATE between 1970 and 1980 to determine species and abundance.
No current shorebird migration monitoring at GATE is known to be occurring.

Waterfowl

The New York Bight accounts for about one-quarter of the Atlantic flyway wintering population. Within this park, the most important wintering area is the Raritan Bay-Sandy Hook Bay area. Jamaica Bay has significant wintering waterfowl concentrations, with mid-winter ground counts over the period from 1980 to 1992 averaging about 11,000 birds, with a peak of 36,000 birds.

No current waterfowl monitoring at GATE is known to be occurring.

Raptors

Breezy Point Hawk Banding Station Breezy Point is a concentration area for raptors, especially during the summer and fall migrations. The raptor banding station at Breezy Point banded a total of 2,414 raptors during the period from 1978 to 1987 and sighted a total of 15,715 raptors.

Fort Tilden Hawk Watch The Fort Tilden Hawk Watch was founded in 1990 and was covered full time during the 1991 through 1995 fall seasons.

Sandy Hook Hawk Watch The Sandy Hook Hawk Watch began in 1979 under the guidance of Cape May Bird Observatory with funding from the U.S. Fish and Wildlife Service. The old hawk watch site was on the mortar battery near the lighthouse but is now too overgrown with vegetation. It was conducted annually until 1994. It was restarted in 1999. Currently, the New Jersey Audubon's Owl Haven Nature Center conducts the Watch from March 15 to May 15 at Fort Hancock on the observation platform overlooking North Pond and the tip of Sandy Hook, near Parking Lot K. Other monitoring programs at GATE and adjacent lands which are listed in Nature BIB include S. Chevalier Snowy Owl populations at Kennedy Airport, unknown date; J. Griffin Osprey and nesting bird report (1974 and 1975); Barn Owl nesting project, 1984; Karen Salesman Osprey breeding Success Program, 1989.

Grassland and Shrubland Birds
In 1985, a portion of Floyd Bennett Field was restored to grassland and now about 57 hectares (140 acres) are maintained through clearing, mowing, and burning. This is one of the few sizable grasslands within the urban core of New York City; it supports a variety of grassland birds, several of which are rare and/or declining in the northeastern United States. Close monitoring of bird populations using this area has occurred since the Floyd Bennett Field restoration.
Data from the R.A. Lent's 1996 Bird-habitat relationships as a guide to ecologically-based management at Floyd Bennett Field, Gateway National Recreation Area studies has been obtained and will be entered into the NPSpecies. An additional 1998 report completed by Susan Elbin of the Wildlife Conservation Society titled *Grassland Birds at Floyd Bennett Field* will be requested from GATE staff for entry into NPSpecies. This report provides data regarding breeding grassland species at Floyd Bennett field in 1996 and 1997. It also described trends in grassland birds using this area from 1985 through 1997.

Marsh Birds

No monitoring programs exists for marsh birds at GATE.

Seabirds

No monitoring programs exists for seabirds at GATE.

Sagamore Hill National Historic Site (SAHI)

Landbird/Neotropical Migrants

BBA and MAPS For SAHI, the BBA Block 6252A also includes some of Lloyd Harbor which is located to the east of SAHI. Theodore Roosevelt Sanctuary located less than two miles from SAHI conducts a MAPS program.

Northern Nassau County Christmas Bird Count has been conducted since 1954 and includes SAHI.

The Theodore Roosevelt Sanctuary also conducts a fall and spring banding station.

Colonial Waterbirds

Aerial surveys, Population trends, BBA In the 1970s, aerial surveys of the Long Island breeding waterbird colonies were conducted. Also, monitoring program regarding population and colony-site trends of Long Island was conducted for five years in the mid-1970s (P.A. and F.G. Buckley, 1980). Additional monitoring programs include the NY BBA (not exclusively SAHI data), Oyster Bay (historic data)/Northern Nassau County CBC (not exclusively SAHI data).

Currently, no long-term monitoring programs focusing on colonial waterbirds are being conducted at SAHI.

Shorebirds
There are no accounts of breeding shorebirds at SAHI. In addition, there are no documented records of any of these parks supporting large numbers of migratory shorebirds most likely due to their location and lack of appropriate habitat.

Waterfowl

SAHI encompasses a 10-acre tidal saltmarsh on Eel Creek that waterfowl may utilize. This saltmarsh is located adjacent to Oyster Bay Harbor where Oyster Bay NWR (OBNWR) is located. Regular waterfowl surveys throughout the year are conducted at OBNWR.
Aside from the CBC and BBA that also included other areas outside of SAHI, no waterfowl inventories or monitoring programs have ever been conducted at SAHI. However, Theodore Roosevelt Sanctuary (TRS) is located adjacent to SAHI and it conducts annual Winter Waterfowl Surveys.

Raptors

Aside from the BBA that also includes other areas outside of SAHI, no raptor inventories or monitoring programs have ever been conducted at SAHI.

Marsh Birds

No monitoring programs for marsh birds have occurred at SAHI.

In 1997, a habitat assessment was conducted at SAHI (Kiviat, 1997). Survey recommendations included in this report were to conduct a breeding bird survey in the beach-marsh complex. It was noted that the saltmarsh had potential for providing nesting habitat for seaside sparrow, black rail and other marsh nesting birds. Currently, TRS is conducting an inventory of this habitat to determine the need for possible long-term monitoring of any bird species utilizing this saltmarsh.

CHAPTER III-CONCEPTUAL MODELS

As part of the Network's monitoring program, a conceptual model will be created for each monitoring protocol developed. The models will identify linkages between indicators and the environmental variables chosen for long-term monitoring in the Network. At this time, the selected monitoring components identified as shoreline change, estuarine nutrient enrichment, contaminants, species and habitats, and visitor impacts are in various stages of development, and conceptual models have not yet been developed for each of these. The Network's marsh community monitoring and estuarine nutrient enrichment components currently have draft conceptual models. A conceptual model for shoreline change will be drafted during a Shoreline Change Scoping Workshop that will be held at the University of Rhode Island in October 2002.

CACO CONCEPTUAL MODELS

In order to provide guidance to the workgroups at the April 2000 Vital Signs Scoping Workshop, and given the similarities between CACO and the other Network parks, the Technical Steering Committee used the four CACO long-term monitoring program design matrices as draft working models to begin a Network based discussion. The Network Technical Steering Committee adopted the design matrices developed for CACO to assist in identifying important issues faced within the four landscape types used as part of both the CACO and Network monitoring frameworks. Each of the matrices presented in the CACO conceptual framework, attempts to explain the complex relationships among what the authors call, agents of change, stressors and ecosystem responses. Agents of change are defined as "natural processes and events, or human activities." They are described as either operating within the range of natural variability and acceptable limits of change, or not. If an agent of change does not stay within its range of natural variability or acceptable limits of change, they then are considered stressors. Stressors are described in the CACO conceptual framework as "the associated problems or products of human activities or natural events (agents) that diminish the quality or integrity of the ecosystem." Finally, ecosystem responses are defined as "detectable changes or trends in any measurable value of the coastal ecosystem's structure, function, or process, that is considered indicative of ecosystem quality or integrity" (Roman and Barrett, 1999) (http://www.nature.nps.gov/im/monitor/caco.pdf). The terminology "vital signs" used at the Coastal and Barrier Network scoping workshop and throughout this report, are what is described in the CACO framework as ecosystem responses.

A simple example of agents of change, stressors and responses within an estuarine ecosystem, is the relationship between septic systems, nutrients and primary productivity within an estuarine habitat:

Agent of change = Septic systems
Stressor = Increase in nutrient loading
Response = Altered primary productivity patterns

In order to develop a preliminary list of agents of change appropriate to all coastal ecosystems, broad categories were considered in developing the CACO framework: Land Use, Natural Disturbances including Physical and Biotic Forces, Pollution, Recreational Use, Resource Extraction and Exploitation, and Unknown Agents of Change (Table 3). These same categories are applicable to almost all of the Northeast Coastal and Barrier Network park ecosystems and were used in discussion at the initial Network Vital Signs scoping workshop. In terms of Natural disturbances, shoreline change was more specifically identified at the workshop.

TABLE 3. *Agents of Change* listed according to broad categories. Taken from the Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore (Roman and Barrett, 1999).

AGENTS OF CHANGE
LAND USE
Construction - dams, dikes, culverts, revetments, *etc*.
Development / Agriculture / Aquaculture
Dredging / Disposal
Dune building / Beach nourishment
Mosquito control
NATURAL DISTURBANCES / PHYSICAL & BIOTIC FORCES
Adverse weather / Storm surges
Fire / Fire suppression
Grazing / Browsing
Ground water influx
Inlet / Landform migration
Sea level rise
Species additions / Species removals (natives & exotics)
UV-B (Solar radiation)
POLLUTION
Atmospheric deposition
Fertilizers / Pesticides
Oil / Toxic spills
Ozone
Septic systems
RECREATIONAL USE
Recreational use - boating, ORVs, trampling, biking, *etc*.
RESOURCE EXTRACTION & EXPLOITATION
Ground water withdrawal
Fishing / Shellfishing
UNKNOWN?

In developing the CACO design matrices, stressors were identified for each of the agents of change, Land Use, Resource Extraction, etc…and management issues relevant to CACO were paired with these stressors (Table 4). As mentioned in the description of the scoping workshop, each Network park submitted their specific list of management issues for discussion at the workshop pertaining to these models. The management issues included in the CACO model are: impacts of adjacent development on groundwater quality and quantity, accelerated rates of freshwater and coastal marine eutrophication, impacts of recreation on natural resources, effects of landscape changes since European settlement, protection and restoration of Federal and/or State-listed rare species and communities, consumptive uses of resources, air pollution, and sea level rise. It is important to remember that any one of these issues may be attributed to several stressors and that any single stressor may relate to several issues. Table 5 provides a preliminary list of ecosystem responses.

TABLE 4. Ecological *Stressors* and their relevancy to Park management issues. Taken from the Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore (Roman and Barrett, 1999).

	Management Issues							
*STRESSORS**	*Groundwater Quality / Quantity*	*Eutrophication*	*Recreational Impacts*	*Human-altered Landscapes*	*Species / Habitat Restoration*	*Resource Consumptive Uses*	*Air Quality / Pollution*	*Sea Level Rise*
PHYSICAL								
Altered tidal circulation				x				x
Freshwater discharge alteration	x			x				
Microclimatic change								
Suspended particles		x	x					
Water table alterations	x	x				x		x
CHEMICAL								
Acidification	x	x			x		x	x
Nutrient loading	x	x	x					
Toxins	x	x					x	
BIOLOGICAL								
Exotics, over/under-abundant spp.					x			
Human presence / conflict			x	x				
Overgrazing / defoliation					x			
Over-harvests (fish / shellfish)						x		

*Note- The tern “stresses” was used in the original CACO document, but has been changed to stressors here to avoid confusion in interpreting later models.

TABLE 5. *Ecosystem Responses* listed according to general categories. Taken from the Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore (Roman and Barrett, 1999).

ECOSYSTEM RESPONSES
BIOGEOCHEMICAL CYCLING
Algal nitrogen content
Freshwater chemistry
Soil chemistry - mineral nutrients, pH, *etc*.
PRODUCTIVITY / BIOMASS CHANGE
Algal production
Eelgrass decline
Freshwater plankton production
Landbird production
Nekton production
Plant biomass
Wildlife production
BIODIVERSITY / ABUNDANCE
Amphibian and reptile abundance
Aquatic invertebrate abundance
Beach invertebrate community change
Benthic community change
Deer abundance
Nekton community change
Small mammals abundance
Vegetation development
Waterbird community change
Red Fox and Coyote abundance
LIFE HISTORY / RARE OR KEY SPECIES
Population dynamics of rare or key species
LANDSCAPE / HABITAT DIVERSITY / ABUNDANCE
Geomorphic change - shoals, shores, dunes, *etc*.
Habitat loss / gain
Hypoxia / Anoxia
Light limitation
UNKNOWN?

Finally, in developing the following design matrices, agents of change, stressors, and ecosystem responses identified in the tables 6a-6d were combined for each of the four ecosystem types; Estuaries and Salt Marshes, Barrier Islands, Spits and Dunes, Ponds and Freshwater Wetlands, and Coastal Uplands. Each of these tables represent some of the known interactions that should be considered for monitoring within each ecosystem type. As the authors state, "The design matrices are not intended to represent a comprehensive account of the entire coastal ecosystem, nor merely a list of mechanisms and outcomes as features of ecosystem change. Instead, they present a conceptual framework to help select and develop monitoring protocols." It is important to keep in mind when developing a plan for monitoring, what is clearly illustrated in these matrices, that multiple ecosystem responses can occur at any one time with multiple agents of change and stressors. Although these matrices were originally developed for Cape Cod National Seashore, cooperators working to develop protocols for the Network

are being asked to refer to these tables and matrices as a basis for developing conceptual models for their particular projects.

Table 6a. The Cape Cod National Seashore Long-term Monitoring Program estuaries and salt marshes design matrix (Roman and Barrett, 1999).

ESTUARIES & SALT MARSHES DESIGN MATRIX								
AGENTS OF CHANGE								
LAND USE								
Construction - dikes, culverts, revetments, *etc*.	x	x	x	x		x		
Development / Agriculture	x	x	x	x		x		
Dredging / Disposal	x		x	x		x	x	
Mosquito control	x		x				x	
NATURAL DISTURB. / PHYSICAL & BIOTIC FORCES								
Adverse weather / Storm surges	x		x	x				
Ground water influx				x				
Inlet / Landform migration	x							
Sea level rise	x							
Species additions/removals (natives & exotics)		x	x					
POLLUTION								
Atmospheric deposition				x			x	
Oil / Toxic spills							x	
Septic systems				x				
RECREATIONAL USE								
Recreational use - boating, ORVs, etc.	x	x	x			x	x	
RESOURCE EXTRACTION & EXPLOITATION								
Fishing / (Shellfishing)		x	x		x			
Ground water withdrawal								
UNKNOWN?								x
STRESSORS	Altered tidal circulation	Human presence / conflict	Exotics, Over- & Under-abundant Spp.	Nutrient loading	Over-harvests (fish/shellfish)	Suspended particles	Toxins	Unknown?
ECOSYSTEM RESPONSES								
BIOGEOCHEMICAL CYCLING								
Porewater chemistry	x			x			x	
Wet deposition chemistry				x				
PRODUCTIVITY / BIOMASS CHANGE								
Algae production	x			x				
Eelgrass decline	x			x		x	x	
Nekton production				x				
BIODIVERITY / COMMUNITY COMPOSITION								
Benthic community change	x		x	x		x	x	
Nekton community change	x	x	x	x	x	x	x	
Vegetation development	x		x	x			x	
Waterbird community change		x	x		x		x	
LIFE HISTORY / KEY OR RARE SPECIES								
Population dynamics of rare or key spp.			x					
LANDSCAPE / HABITAT DIVERSITY / ABUNDANCE								
Geomorphic change - shoals, shores, *etc*.	x							
Habitat loss / gain	x							
Hypoxia / Anoxia	x			x				
Light limitation						x		
UNKNOWN?								x

Table 6b. The Cape Cod National Seashore Long-term Monitoring Program barrier islands, spits and dunes design matrix (Roman and Barrett, 1999).

BARRIER ISLANDS, SPITS, & DUNES DESIGN MATRIX									
AGENTS OF CHANGE									
LAND USE									
Construction - dikes, culverts, revetments, *etc*.		x	x	x		x			
Development / Agriculture		x	x	x		x	x	x	
Dredging / Disposal				x		x	x		
Dune Building / Beach nourishment			x			x		x	
NATURAL DISTURB. / PHYSICAL & BIOTIC FORCES									
Adverse weather / Storm surges			x	x		x			
Fire / Fire suppression			x			x			
Inlet / Landform migration			x			x			
Sea level rise								x	
Species additions / removals (natives & exotics)		x			x	x			
POLLUTION									
Atmospheric deposition	x			x			x		
Oil / Toxic spills							x		
Ozone			x				x		
Septic systems				x					
RECREATIONAL USE									
Recreational use - trampling, ORVs, *etc*.		x				x	x		
RESOURCE EXTRACTION & EXPLOITATION									
Ground water withdrawal								x	
UNKNOWN?									x
STRESSORS	Acidification	Human presence / conflict	Microclimatic change	Nutrient loading	Overgrazing / defoliation	Exotics, Over- & Under-abundant Spp.	Toxins	Water table alterations	unknown?
ECOSYSTEM RESPONSES									
BIOGEOCHEMICAL CYCLING									
Wet deposition chemistry	x		x	x					
Soil chemistry	x			x					
PRODUCTIVITY / BIOMASS CHANGE									
PLANT BIOMASS	x	x	x	x	x			x	
BIODIVERSITY / ABUNDANCE									
Beach invertebrate community change		x				x	x		
Deer abundance		x			x		x		
Landbird population change		x				x	x		
Small mammals abundance					x	x	x		
Vegetation development	x	x	x	x	x	x	x	x	
Waterbird abundance change		x				x	x		
Wildlife abundance		x				x	x		
LIFE HISTORY / KEY OR RARE SPECIES									
Population dynamics of rare or key species						x			
LANDSCAPE / HABITAT DIVERSITY / ABUNDANCE									
Geomorphic change - shores, dunes, *etc*.			x					x	
Habitat loss / gain	x		x						
UNKNOWN?									x

Table 6c. The Cape Cod National Seashore Long-term Monitoring Program ponds and freshwater wetlands design matrix (Roman and Barrett, 1999).

PONDS & FRESHWATER WETLANDS DESIGN MATRIX												
AGENTS OF CHANGE												
LAND USE												
Construction - dams, culverts, *etc*.		x	x	x			x	x	x		x	
Development / Agriculture		x	x	x			x	x	x	x	x	
Dredging / Disposal				x			x	x	x	x		
Mosquito control							x	x		x		
NATURAL DISTURB. / PHYSICAL & BIOTIC FORCES												
Adverse weather / Storm surges			x	x			x	x	x		x	
Grazing / Browsing					x		x					
Ground water influx				x				x			x	
Species additions / removals (natives & exotics)		x			x		x					
UV-B (Solar radiation)			x				x					
POLLUTION												
Atmospheric deposition	x			x						x		
Fertilizers / Pesticides				x						x		
Oil / Toxic spills										x		
Septic systems				x								
RECREATIONAL USE												
Recreational use - boating, ORVs, *etc.*		x		x			x		x			
RESOURCE EXTRACTION & EXPLOITATION												
Fishing		x				x	x					
Ground water withdrawal												
UNKNOWN?												x
STRESSORS	Acidification	Human presence / conflict	Microclimatic change	Nutrient loading	Overgrazing	Over-harvests (fish/shellfish)	Exotics, Over- & Under-abundant Spp.	Stage / discharge alteration	Suspended particles	Toxins	Water table alterations	Unknown?
ECOSYSTEM RESPONSES												
BIOGEOCHEMICAL CYCLING												
Freshwater chemistry	x			x						x		
PRODUCTIVITY / BIOMASS CHANGE												
Macrophyte production	x		x	x		x	x		x	x		
Freshwater plankton production	x		x	x		x	x		x	x		
BIODIVERSITY / ABUNDANCE												
Amphibian & reptile abundance	x	x	x				x	x		x	x	
Aquatic Invertebrate abundance	x	x	x	x			x	x		x		
Fish community change	x	x				x	x	x	x	x		
Vegetation development	x	x	x	x	x		x	x		x	x	
LIFE HISTORY / KEY OR RARE SPECIES												
Population dynamics of rare or key species							x					
LANDSCAPE / HABITAT DIVERSITY / ABUNDANCE												
Geomorphic change - shorelines, *etc*.			x								x	
Habitat loss / gain			x					x		x	x	
Hypoxia / Anoxia	x			x				x				
UNKNOWN?												x

Table 6d. The Cape Cod National Seashore Long-term Monitoring Program coastal uplands design matrix (Roman and Barrett, 1999).

COASTAL UPLANDS DESIGN MATRIX									
AGENTS OF CHANGE									
LAND USE									
Construction - clearing, *etc*.		x	x			x		x	
Development / Agriculture		x	x	x	x	x	x		
Dredging / Disposal				x		x	x		
NATURAL DISTURB. / PHYSICAL & BIOTIC FORCES									
Adverse weather / Storm surges			x	x		x			
Fire / Fire suppression			x	x		x		x	
Grazing / Browsing					x	x			
Species additions/removals (natives & exotics)		x			x	x			
POLLUTION									
Atmospheric deposition	x			x					
Fertilizers / Pesticides						x	x		
Oil / Toxic spills						x	x		
Ozone			x			x	x		
RECREATIONAL USE									
Recreational use - ORVs, trampling, *etc*.		x				x			
RESOURCE EXTRACTION & EXPLOITATION									
UNKNOWN?									x
STRESSORS	Acidification	Human presence / conflict	Microclimatic change	Nutrient loading	Overgrazing	Exotics, Over- & Under-abundant	Toxins	Water table	Unknown?
ECOSYSTEM RESPONSES									
BIOGEOCHEMICAL CYCLING									
Soil chemistry - mineral nutrients, pH, *etc*.	x		x	x					
PRODUCTIVITY/ BIOMASS CHANGE									
Plant biomass	x	x	x	x	x	x		x	
Landbird production		x	x			x	x		
BIODIVERSITY / ABUNDANCE									
Amphibian & reptile abundance		x				x	x		
Deer abundance		x			x	x			
Invertebrate abundance		x	x			x	x		
Red Fox and Coyote abundance		x				x			
Landbird population change		x	x			x	x		
Small mammals abundance					x	x			
Vegetation development	x	x	x	x	x	x	x	x	
Wildlife production		x				x			
LIFE HISTORY / KEY OR RARE SPECIES									
Population dynamics of rare or key spp.						x			
LANDSCAPE / HABITAT DIVERSITY / ABUNDANCE									
Geomorphic change								x	
Light variation						x			
Habitat loss / gain			x				x		
UNKNOWN?									x

CONCEPTUAL MODEL DEVELOPMENT FOR THE NETWORK

Any of the relationships among agents of change, stressors and ecosystem responses identified in these matrixes can be represented in flow chart format, a typical presentation for conceptual models, and many conceptual flow chart models can be developed from these matrixes. It is important to remember that linkages among agents of change, stressors and ecosystem responses can be presented in a variety of ways within these models, and that one conceptual model is not necessarily more correct than another. A conceptual model should be a visual or narrative summary that describes the important components of the ecosystem and the interactions among them. Development of these model helps in understanding how the diverse components of a monitoring program interact, and promotes integration and communication among scientists and managers from different disciplines.

Currently two projects funded by the Northeast Coastal and Barrier Network have developed draft conceptual models. (The project titles are: *Candidate Variables for Monitoring Estuarine Nutrient Enrichment within the NPS Coastal and Barrier Network,* and *Implementing Long-Term Monitoring of Salt Marsh Communities within the Northeast Coastal and Barrier Network of the National Park Service).* These models were created to convey the relationships between ecosystem components specific to each monitoring protocol. These three models (two models are included in the salt marsh project) may be modified or refined for the Network as the protocols are tested and implemented region-wide across the parks. For each monitoring component, a brief description is provided followed by the model.

Estuarine Nutrient Enrichment Conceptual Model

Nutrient enrichment of the coastal zone in the Northeast Coastal and Barrier Network parks is due to many factors relating to population growth including, land clearing, fertilizer production and application, discharge of sewage and septic systems, and fossil fuel combustion (Nixon 1995, Cloern 2001). The consequent residential, agricultural, and urban expansion will result in a continued increase in anthropogenic nutrient loading to the coastal ecosystems of these park's. Estuaries can generally assimilate some degree of enrichment without major ecological ramifications, but excessive nutrient inputs typically lead to dense blooms of phytoplankton and fast-growing macroalgae, loss of seagrasses, and decreased oxygen availability in sediments and bottom waters (Valiela et al. 1992, Nixon 1995, Borum 1996, Bricker et al. 1999). Cascading effects may include changes in the species composition and abundance of invertebrates, decline in fish and wildlife habitat value, and the collapse of commercially harvestable fin- and shellfish stocks.

The following model was drafted for the CACO monitoring program and has been adopted as a draft model depicting nutrient enrichment for the Network's monitoring program (Figure 10). This model identifies three agents of change, septic systems, atmospheric deposition and development and fertilizer that are known causes of nutrient enrichment within estuarine ecosystems along the Atlantic coast. The ecosystem response, identified in this model as, algal production, is depicted here as a direct response to the effects of nutrient enrichment on the estuarine ecosystem.

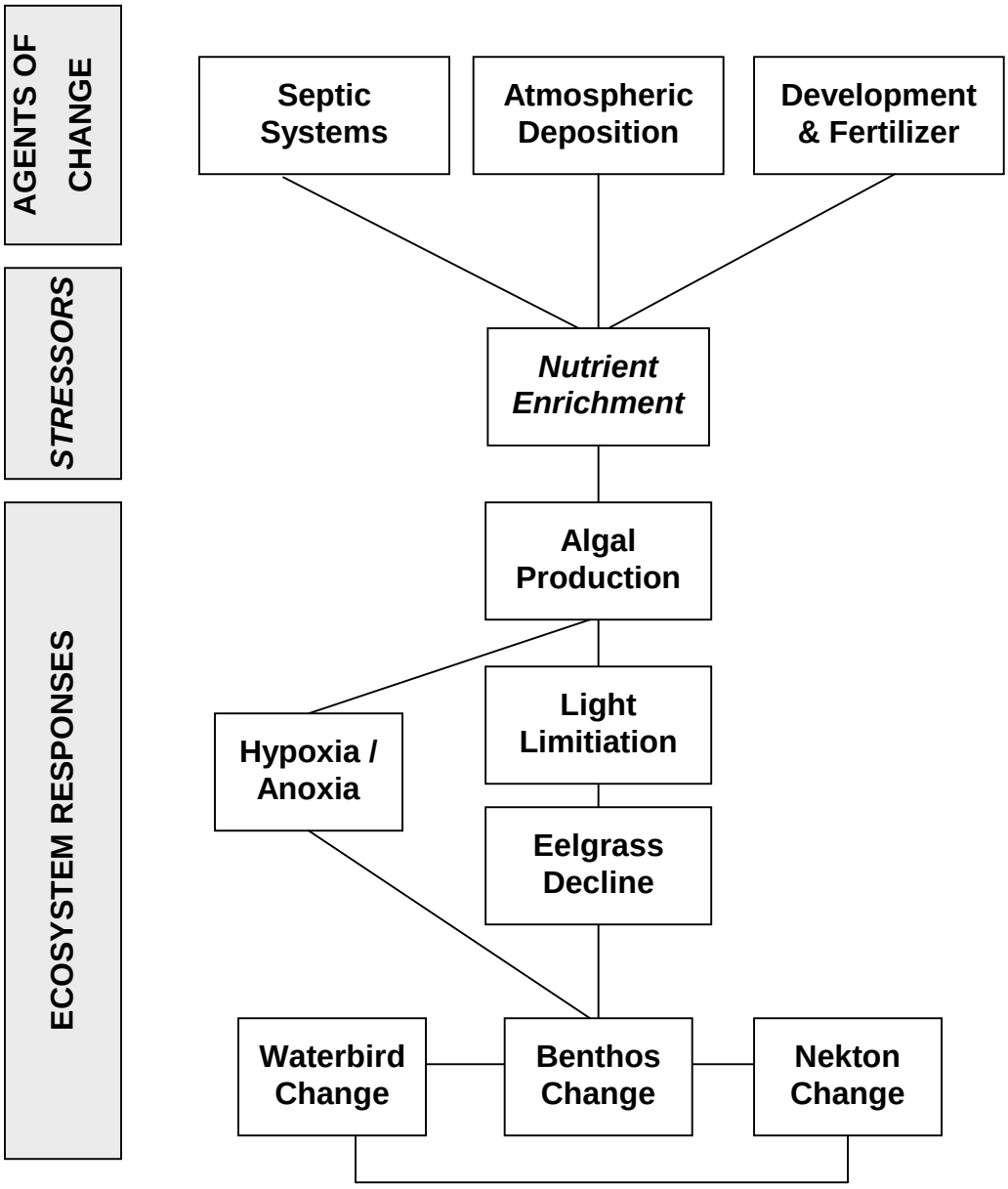

Figure 10. Conceptual model depicting the linkages among agents of change, stressors, and ecosystem responses associated with nutrient enrichment.

Conceptual Models for Salt Marsh Community monitoring

The following draft conceptual models were created as part of two monitoring protocols, *Monitoring Nekton in Shallow Estuarine Habitats* (Raposa & Roman 2000) (http://www.nature.nps.gov/im/monitor/caco_nekton.pdf) and *Monitoring Salt Marsh Vegetation* (Roman et al. 2001) (http://www.nature.nps.gov/im/monitor/caco_marshveg.pdf) implemented at CACO. These two protocols are also currently implemented on several US Fish and Wildlife Refuges along the Atlantic Coast, and have been adopted as part of the salt marsh community monitoring component in the Northeast Coastal and Barrier Network parks.

Estuarine Nekton Monitoring

As indicated by numerous studies, nekton, have been proven to be excellent indicators (vital signs) of estuarine health. They tend to respond to a variety of ecosystem changes resulting from numerous anthropogenic impacts, including, salt marsh hydrologic changes, nutrient loading, and overfishing (Raposa and Roman. 2001). Nekton, assemblages of fishes and decapod crustaceans, is an abundant estuarine fauna. They play a unique role in the estuarine ecosystem as an important link among primary producers, consumers, and top predators. They represent a significant portion of piscivorous bird, economically valuable fish, and when in estuaries, marine mammal diets.

The following conceptual model (Figure 11) identifies some known agents of change, altered hydrology, geomorphic processes, pollution/urbanization and global climate change and their associated stressors, salinity changes, water quality degradation, nutrient loading, etc…that result in habitat change and in turn changes to nekton communities.

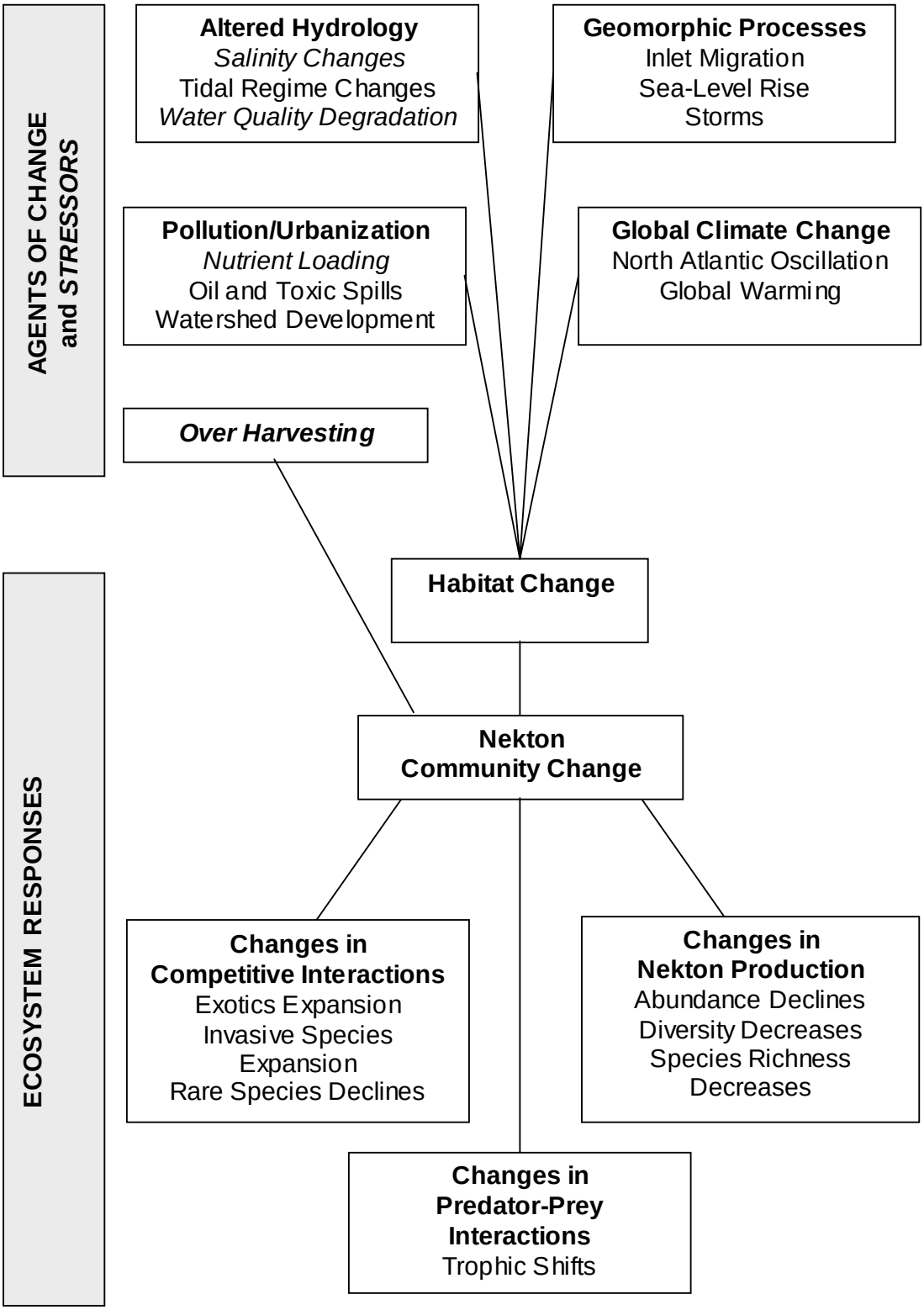

Figure 11. Conceptual model illustrating the linkages among agents of change, stressors and nekton community responses.

Salt Marsh Vegetation Monitoring

Salt marshes throughout the Northeast provide essential nursery habitat for recreational and commercial fishery species. They have a long history of alteration ranging from ditching for mosquito control, salt hay farming, hydrological alterations due to construction of roads, causeways, bridges and dikes and of course dramatic development of their associated watersheds (Daiber 1986, Roman *et al.* 2000). Salt marsh vegetation undergoes dramatic changes in species composition due to these alterations, which in turn alters the role of the marsh in the overall coastal ecosystem. Shifts in dominant vegetation types to species such as *Phragmites austalis* due to tidal flow restrictions or high marsh shrub species due to ditching, affect the role of the salt marsh in supporting migratory shorebirds and water birds for example, and the ability to serve as nutrient filters from land run-off.

Figure 12 shows some of the known linkages between human-induced and natural environmental agents of change and stressors and the associated responses of salt marsh plant communities.

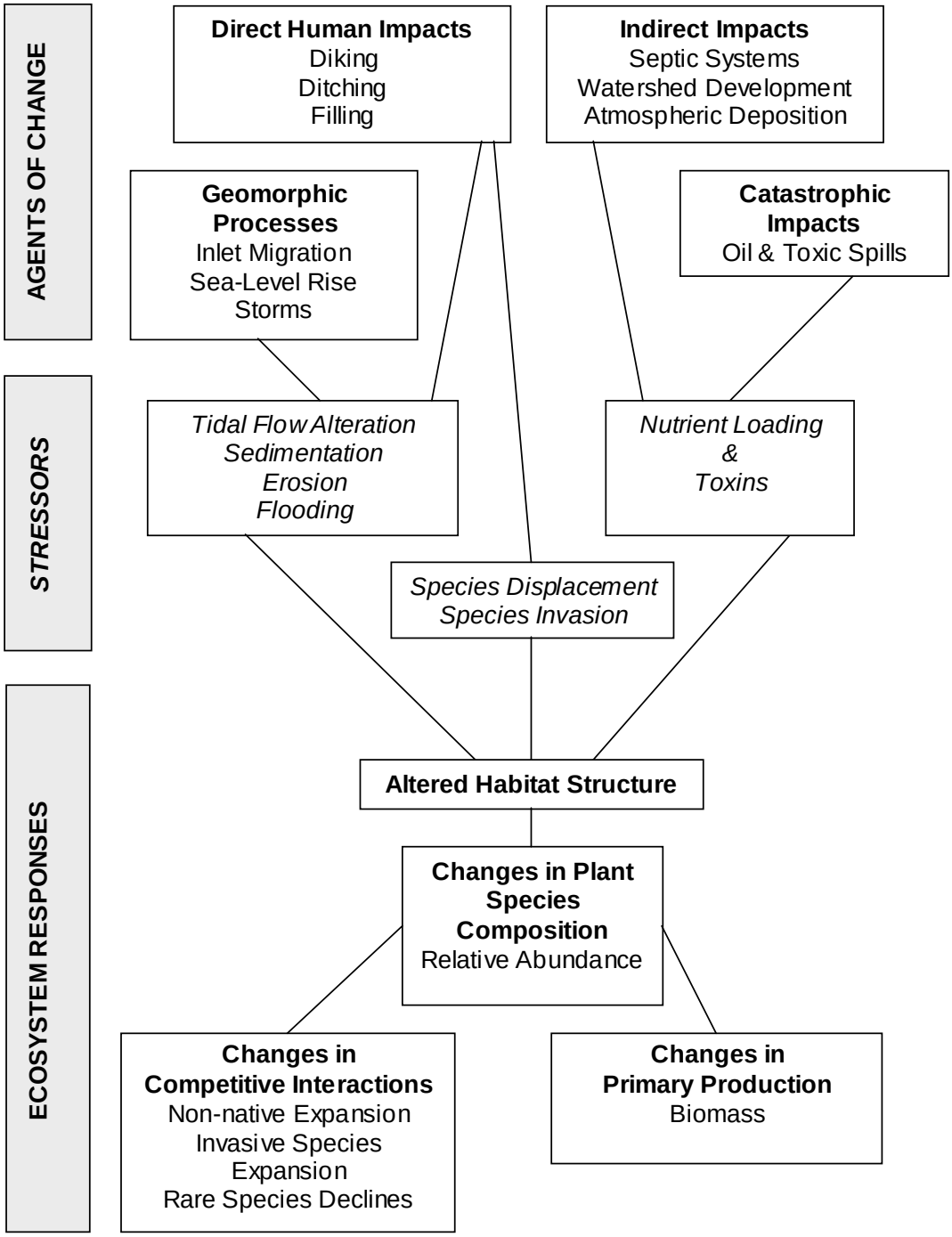

Figure 12. Conceptual model illustrating the linkages among agents of change, stressors and associated ecosystem responses in plant species composition.

LITERATURE CITED

Andrews, R. 1990. Coastal waterbird colonies: Maine to Virginia, 1984-1985. An update of an atlas based on 1977 data, showing colony locations and species composition at both time periods, with examination of changes in regional populations. U.S. Fish and Wildlife Service, Newton Corner, MA.

Andrle, R.F. and J.R. Carroll (eds.) 1988. The Atlas of Breeding Birds in New York State. A project of the Federation of New York State Bird Clubs, Inc., New York State Department of Environmental Conservation, and Cornell Laboratory of Ornithology. Cornell University Press, Ithaca, NY. 551p.

Askins, R. A. 1993. Population trends in grassland, shrubland, and forest birds in eastern North America. Pages 1-34 in D. M. Power , editor. Current Ornithology, Volume 11. Plenum Press, New York.

Askins, R.A., J.F. Lynch, and R. Greenberg. 1990. Population declines in migratory birds in eastern North America. Current Ornithology 7:1-57.

Ayvazian, S. G., L. A. Deegan, and J. T. Finn. 1992. Comparison of habitat use by estuarine fish assemblages in the Acadian and Virginian zoogeographic provinces. *Estuaries* 15: 368-383.

Barclay, J.S. and D.F. Squires. 1991. Wildlife habitats and populations in the New York/New Jersey estuary. Report to New York/New Jersey Harbor Estuary Program.

Bass, K. H. 1978. Sprague's Pipit at Chincoteague. Raven 49:36-37.

Bellrose, F.C. 1980. Ducks, geese, and swans of North America, third edition. A Wildlife Management Institute book sponsored jointly with the Illinois Natural History Survey. Stackpole Books, Harrisburg, PA.

Belval, D.L., K. Keppler, and M.D. Flora. 1997. Water Resources Management Plan: George Washington Birthplace National Monument, Virginia. U.S. National Park Service. 67 pp.

Bent, A.C. 1992. Life histories of North American shorebirds. Part 2. U.S. Natl. Mus. Bull. 146.

Bollinger, E. K. 1996. The effects of habitat selection and vegetation succession on the breeding dispersion of birds nesting in eastern hayfields. Auk 112:720-730.

Bollinger, E. K. and T. A. Gavin. 1989. The effects of site quality on breeding-site fidelity in Bobolinks. Auk 106:584-594.

Bollinger, E. K. and T. A. Gavin. 1992. Eastern Bobolink populations: ecology and conservation in an agricultural landscape. Pages 497-506 in J. M. Hagan,III and D. W. Johnston , editors. Ecology and conservation of neotropical migrant landbirds. Smithsonian Institute Press, Washington, D.C.

Bollinger, E. K., P. B. Bollinger, and T. A. Gavin. 1990. Effects of hay-cropping on eastern populations of the Bobolink. Wildlife Society Bulletin 18:142-150.

Bollinger, E. K., T. A. Gavin, and D. C. McIntyre. 1988. Comparison of transects and circular-plots for estimating Bobolink densities. Journal of Wildlife Management 52:777-786.

Bonney, R., D. N. Pashley, R. Cooper, and L. Niles, eds. 1999. Strategies for bird conservation: the Partners in Flight planning process. Cornell Lab of Ornith. http://birds.cornell.edu/pifcapemay

Bricker, S.B., C.G. Clement, D.E. Pirhalla, S.P. Orlando, and D.R.G. Farrow. 1999. National estuarine nutrient enrichment assessment: a summary of conditions, historical trends, and future outlook. National Oceanic and Atmospheric Administration. Silver Springs, MD 70 pp.

Brown, Jennifer M. 1994. Species Composition, Migration chronology and Habitat Use of Waterbirds at Cape Cod National Seashore. Master's Thesis. Natural Resources Science, University of Rhode Island.

Buckley, P.A. and F.G. Buckley. 1980. Population and colony-site trends of Long Island waterbirds for five years in the mid-1970s. Transactions of the Linnaean Society of New York 9:23-56.

Buckley, P.A., and F.G. Buckley. 1984. Seabirds of the North and Middle Atlantic coasts of the United States: their status and conservation. Pp. 101-133 in Croxall, J., P. Evans and R. Schreiber, eds. Status and conservation of the world's seabirds. ICBP Technical Report No. 2. Cambridge, England, ICBP. 778pp.

Burger, J. 1984. Abiotic factors affecting migrant shorebirds. In J. Burger and B.L. Olla (eds.) Behavior of marine animals, vol. 6, shorebirds: migration and foraging behavior, pp. 1-72. Plenum Press, New York, NY.

Burger, J. 1991. Coastal landscapes, coastal colonies and seabirds. Reviews in Aquatic Sciences 4(1): 23-43.

Burger, J. and M. Gochfeld. 1983. Jamaica Bay studies 5: Flocking associations and behavior of shorebirds at an Atlantic coastal estuary. Biology of Behavior 8:289-318.

Burger, J., R. Trout, W. Wander, and G.S. Ritter. 1984. Jamaica Bay studies 7: Factors affecting the distribution and abundance of ducks in a New York estuary. Estuarine, Coastal and Shelf Science 19:673-689.

Cape May Bird Observatory. 1995. Avalon sea watch data for 1995. Unpublished data.

Carter, M.F., W.C. Hunter, D.N. Pashley, and K.V. Rosenberg. 2000. Setting conservation priorities for landbirds in the United States: the Partners in Flight approach. Auk 117: 541-548.

Center for Natural Areas. 1977. A summary and analysis of environmental information on the continental shelf from the Bay of Fundy to Cape Hatteras. Vol. 1, bk. 3: xv. Prepared for the Bureau of Land Management by the Center for Natural Areas, S. Gardiner, ME.

Clark, K., L. Niles, and J. Burger. 1993. Abundance and distribution of shorebirds migrating on Delaware Bay, 1986-1992. The Condor 95:694-705.

Colonial Waterbird Monitoring of NY and NJ coastal areas-(1971-1990)) Rutgers University. All colonies in NJ and selected colonies on western LI/ground surveys ??Sandy Hook and Jamaica Bay Complex

Culliton, T. J., C. M. Blackwell, D. G. Remer, T.R. Goodspeed, M.A. Warren. 1989. Selected characteristics in coastal states, 1980-2000. NOAA's Coastal Trends Series: Report 1. National Oceanic and Atmospheric Administration, Strategic Assessment Branch, Rockville, MD. 15pp.

Culliton, T. J., M.A. Warren, T.R. Goodspeed, D.G. Remer C. M. Blackwell, J.J. McDonough III. 1990. 50 years of Population Change Along the Nation's Coasts, 1960-2010. National Oceanic and Atmospheric Administration, Strategic Assessment Branch, Rockville, MD. 41pp.

Daiber, F. C. 1986. Conservation of tidal marshes. Van Nostrand Reinhold Co., New York.

Davis, Thomas H., Taft, David, Riepe, Don. 1996. No Title. Pages in No Author. Birds of the Jamaica Bay Wildlife Refuge. Gateway National Recreation Area, National Park Service, US Department of the Interior, Brooklyn, NY.

Dean, R.G. 1979. Effects of vegetation on shoreline erosional processes, p. 415-426. In P.E. Greeson, J.R. Clark and J.E. Clark (eds.), Wetland Functions and Values: The State of our Understanding. American Water Resources Association, Minneapolis, MN.

Denslow, J. S. 1985. Disturbance-mediated coexistence of species. Pages 307-323 *in* S. T. A. Pickett and P.S. White (Eds.), The Ecology of Natural Disturbance and Patch Dynamics. Academic Press, NY.

Dillow, J.J.A. and E.A. Greene. 1999. Ground-Water Discharge and Nitrate Loadings to the Coastal Bays of Maryland. USGS Water-Resources Investigations Report 99-4167. 8 pp.

Doering, P.H. and C.T. Roman. 1994 Nutrients in Somes Sound and the associated watershed, Mount Desert Island, Maine. National Park Service, North Atlantic Region, Boston, MA. Technical Report NPS/NAROSS/NRTR-94-22 56pp.+appendicies.

Doering, P.H., C.T Roman, L.L. Beatty, A.A. Keller, and C.A. Oviatt. 1994. Water Quality and

Habitat Evaluation of Bass Harbor Marsh, Acadia National Park, Maine. National Park Service, North Atlantic Region, Boston, MA. Technical Report NPS/NESORNR/NRTR-95-31 147pp.+appendicies.

Droege, S. 1990. The North American Breeding Bird Survey. Pp. 1-4 in J. R. Sauer and S. Droege, eds. Survey designs and statistical methods for the estimation of avian population

Duebbert, H. F. and J. T. Lokemoen. 1977. Upland nesting of American Bitterns, Marsh Hawks, and Short-eared Owls. Prairie Naturalist 9:33-40.

Dunne, P., R. Kane, and P. Kerlinger. 1989. New Jersey at the crossroads of migration. New Jersey Audubon Society, Franklin Lakes, NJ. 74 p.

Elliot, R. (Ed.). 1997. Conservation issues for North American sea ducks - a concept paper for a sea duck joint venture under the North American Waterfowl Management Plan. CWS, USFWS, USGS-BRD. 41pp.

England, M. E. 1989. The breeding biology and status of the northern harrier (Circus cyaneus) on Long Island, New York. Master's thesis, Long Island University, C.W. Post Center, Greenvale, NY.

Erwin, R.M. and C.E. Korschgen. 1979. Coastal waterbird colonies: Maine to Virginia, 1977. An atlas showing colony locations and species composition. U.S. Fish and Wildlife Service, Biological Services Program, FWS/085-79/08.

Erwin, R.M., J. Galli, and J. Burger. 1981. Colony site dynamics and habitat use in Atlantic Coast Seabirds. Auk 98:550-561.

Feustal, K. Undated. The history of the Captree Christmas Bird Count (1962-1989). Unpublished report. (need to obtain from the CBC if possible)

Fire Island National Seashore Resource Management Plan. 1998.

Flora, M.D. 2002. Boston Harbor Islands – A National Park Area, Massachusetts: Water Resources Scoping Report. Review Draft Technical Report NPS/NRWRD/NRTR-2—2/xxx.

FOB 2001. Friends of the Bay volunteer Water Quality Monitoring Program 2000 annual report. Oyster Bay, NY. 27pp.

Haig, S.M. 1992. Piping Plover. Pp. 1-22 in: The Birds of North America, No. 2 (A. Poole, P. Settenheim, and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences:Washington, D.C.: The American Ornithologists' Union.

Harbor Herons Project. (1986-1990) Kathy Parsons- Manomet Bird Observatory. Surveyed wader colony sites and surrounding wetland habitat including some islands in GATE.

Harrington, B. and E. Perry. 1995. Important shorebird staging sites meeting Western Hemisphere Shorebird Reserve Network criteria in the United States. Wildlife Habitat Canada and Western Hemisphere Shorebird Reserve Network, Manomet Observatory, Manomet, MA. Working draft.

Harrington, B.A, J.P. Myers, and J.S. Grear. 1989. Coastal refueling sites for global bird migrants. Coastal Zone '89, Proceedings of the Symposium of Coastal and Ocean Management, pp. 4293-4307. American Society of Civil Engineers, New York, NY.

Harrington, B.A. and J.L. Lyons. 1990. On the importance of wildlife areas in the United States to shorebirds migrating east of the 105th longitude line. Draft report prepared for the National Fish and Wildlife Foundation, Washington, D.C. Manomet Bird Observatory, Manomet, MA.

Hayman, P., J. Marchant, and T. Prater. 1986. Shorebirds: an identification guide to the waders of the world. Houghton Mifflin, Boston, MA.

Helmers, D.L. 1992. Shorebird management manual. Western Hemisphere Shorebird Reserve Network. Manomet, MA. 58 p.

Holling, C. S. 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4: 1-23.

Holmes, T. L., R. L. Knight, L. Stegall, and G. R. Craig. 1993. Responses of wintering grassland raptors to human disturbance. Wildlife Society Bulletin 21:461-468.

Hoopes, E.M., P.M. Cavanagh, C.R. Griffin, and J.T. Finn. 1994. Synthesis of information on marine and coastal birds of the Atlantic coast: abundance, distribution, and potential risks from oil and gas activities, 3 vols. Prepared by Massachusetts Cooperative Fish and Wildlife Research Unit, University of Massachusetts, Amherst, MA. Prepared for U.S. Department of the Interior, Minerals Management Service, Herndon, VA.

Howe, M.A., P.H. Geissler, and B.A. Harrington. 1989. Population trends of North American shorebirds based on the International Shorebird Survey. Biological Conservation 49:185-199.

Howe, M.A., R.B. Clapp, and J.S. Weske. 1978. Marine and coastal birds. Marine Ecosystems Analysis Program, New York Bight Atlas Monograph 31. New York Sea Grant Institute, Albany, NY.

Howes, B.L., P.K. Weiskel, D.D. Goehringer and J.M. Teal. 1996. Interception of freshwater and nitrogen transport from uplands to coastal waters: the role of saltmarshes, p. 287-310. *In,* K.F. Nordstrom & C.T. Roman (eds.), Estuarine Shores: Evolution, Environments and Human Alterations. John Wiley & Sons, NY.

James City County 2001. Powhatan Creek Watershed Management Plan Summary Document. James City County, James River Association, and the Center for Watershed Protection.

James, F.C., and H.H. Shugart, Jr. 1970. A quantitative method of habitat description. Aud. Field Notes 24:727-736.

Jenkins, C.D., Jr., L.J. Niles, and J. Wessel. 1990. Survey of colonial nesting waterbirds on the Atlantic Coast of New Jersey - 1989. New Jersey State Department of Environmental Protection, Division of Fish, Game and Wildlife, Endangered and Nongame Species Program, Trenton, NJ.

Jones, C.R. and J.R. Shubel. 1980. Distribution of surficial sediment and eelgrass in Great South Bay, New York, from Smith Point, west to Wantagh State Parkway. Marine Sciences Research Center Special Report 39. State University of New York, Stony Brook, NY 19 pp.

Kahl, S., D. Manski, M. Flora, and N. Houtman, eds. 2000. Water Resources Management Plan: Acadia National Park, Mount Desert Island, Maine. Bar Harbor, Maine.

Kane, R. and P. Kerlinger. 1993. Raritan Bay habitat and wildlife inventory, 1992-1993. New Jersey Audubon, Bernardsville, NJ.

Kane, R. and P. Kerlinger. 1994. Raritan Bay wildlife habitat report with recommendations for conservation. New Jersey Audubon Society, Bernardsville, NJ. 24 p.

Karlson, K. 1989. Sandy Hook fallout. New Jersey Audubon Society Records of New Jersey Birds 15:2.

Kearney, S.B., Cook, R.P. 2001. Status of Grassland and Heathland Birds at Cape cod National Seashore, Massachusetts. Unpublished report.

Kehoe, P. 1994. Status of sea ducks in the Atlantic Flyway. Ad Hoc Sea Duck Committee. Unpub. Report. 71pp.

Kinney, E.H., and C.T. Roman. 1998. Response of primary producers to nutrient enrichment in a shallow estuary. Marine Ecology Progress Series 163:89-98.

Kirkpatrick, Roy L., E.E. Connor, and J.M. Morton. 1992. Waterfowl Population Assessment at Assateague Island National Seashore. Cooperative Agreement 4000-9-8014 SA 17. National Park Service. Philadelphia, PA.

Kopp, B.S., H.A. Neckles, C.T. Roman, and S.W. Nixon. Candidate Variables for Monitoring Estuarine Nutrient Enrichment within the NPS Coastal and Barrier Network. USGS Patuxent Wildlife Research Center, University of Rhode Island. p. 28.

Kramer, G. 1994. Sea goose elusive. Birder's World, June 1994.

Kropp, R.K., R.J. Diaz, D.T. Dahlen, J.D. Boyle, and C.D. Hunt. 2000. 1999 Harbor Benthic Monitoring Report. ENQUAD Report No. 2001-03. Boston: Massachusetts Water Resources Authority 94 pp. + appendices.

Leamond, C.E., R.J. Haefner, S.J. Cauller, and P.E Stackelberg. 1992. Ground-water quality in five

areas of differing land use in Nassau and Suffolk counties, Long Island, New York. U.S. Geological Survey Open file Report 91-180 67p

Leck, C.F. 1985. Pelagics off New Jersey. New Jersey Audubon Society Records of New Jersey Birds 11(1):2-4.

Lent, R.A. 1996. Bird-habitat relationships as a guide to ecologically-based management at Floyd Bennett Field, Gateway National Recreation Area. Conducted by the Seatuck Research Program in cooperation with Gateway National Recreation Area, National Park Service, U.S. Department of the Interior. Seatuck Foundation, Islip, NY. Draft.

LISS 2000. A total maximum daily load analysis to achieve water quality standards for dissolved oxygen in Long Island Sound. New York State Department of Environmental Conservation and Connecticut Department of Environmental Protection. 73 p.

Litwin, T.S., A. Ducey-Ortiz, R.A. Lent, and C.Liebelt. 1993. 1990-1991 Long Island colonial waterbird and piping plover survey. Conducted by New York State Department of Environmental Conservation in cooperation with the Seatuck Research Program.

Long Island colonial waterbird and piping plover surveys. Research reports of the New York State Department of Environmental Conservation, Stony Brook, NY. (authors change annually).

Mabey, S.E., J. McCann, L.J. Niles, C. Bartlett, P. Kerlinger. 1993. The Neotropical migratory songbird coastal corridor study final report. A report of the Virginia Department of Environmental Quality to the National Oceanic and Atmospheric Administration Office of Ocean and Coastal Resource Management pursuant to NOAA award #NA90AA-H-CZ839.

MacIvor, L. et. al. 1987. Wildlife investigations on South Beach Island, Chatham: a progress report. UMASS, Amherst, MA.

MacLean, D.C., T.S. Litwin, A.M. Ducey-Ortiz, and R.A. Lent. 1991. Nesting biology, habitat use, and inter-colony movements of the least tern (Sterna antillarum) on Long Island, N.Y. Conducted by the Seatuck Research Program in cooperation with the New York State Department of Environmental Conservation, Stony Brook, NY.

Maryland Coastal Bays Program (MCBP) 1999. Maryland Coastal Bays Program Nutrient enrichment Monitoring Plan. Appendix A of the Maryland Coastal Bays Comprehensive Conservation Management Plan.

Massachusetts Institute for Social and Economic Research (MISER) 1999. Population projections by the Massachusetts Institute for Social and Economic Research, University of Massachusetts Amherst, MA. http://www.umass.edu/miser/population/ Stefan Rayer demographer.

MCBP 1998a. Maryland Coastal Bays Program, Base Program Analysis: An Analysis of Existing Authorities Affecting Maryland's Coastal Bays, Maryland Department of Natural Resources. (MCBP 98-01).

MCBP 1998b. Compendium of Monitoring and Assessment Programs in the Maryland Coastal Bays, Maryland Department of Natural Resources. (MCBP 98-02)

McHugh, J. L. 1966. Management of estuarine fisheries. *Transactions of the American Fisheries Society Suppl*. 95: 133-154.

MDE and DNR 2000. Maryland Water Monitoring Strategy. Maryland Department of the Environment & Maryland Department of Natural Resources. December 2000

Morimoto, D. C. and F. E. Wasserman. 1991. Intersexual and interspecific differences in the foraging behavior of Rufous-sided Towhees, Common Yellowthroats and Prairie Warblers in the pine barrens of southeastern Massachusetts. Journal of Field Ornithology 62:436-449.

Murphy, R.C. 1967. Distribution of North Atlantic pelagic birds. Serial Atlas of the Marine Environment, folio 14. American Geographical Society.

Muzio, J.N. and R.N. Rubel. 1993. Gateway National Recreation Area Inventory of Submerged Natural Resources and Review of Key Issues. 65pp.

MWRA 1997 Massachusetts Water Resources Authority effluent outfall monitoring plan: Phase II post

discharge monitoring. 92p.Mathieson, A.C., C.J. Dawes, and E.J. Hehre. 1998. Floristic and zonation studies of seaweeds from Mount Desert Island, Maine: an historical comparison. Rhodora, 100(904):333-379.

NERR 2001. The National Estuarine Research Reserve's System-Wide Monitoring Program (SWMP): A Scientific Framework and Plan for Detection of Short-Term Variability and Long-Term Changes in Estuaries and Coastal Habitats of the United States. 45 pp.

New Jersey Audubon Society. 1995. New Jersey breeding bird atlas data from 1993 and 1994. Unpublished data, Cape May, NJ.

New Jersey State Department of Environmental Protection. 1996. Unpublished 1995 colonial waterbird survey data. Endangered and Nongame Species Program, Trenton, NJ.

New York State Department of Environmental Conservation. Long Island colonial waterbird and piping plover survey. A research report of the New York State Department of Environmental Conservation, Stony Brook, NY. (Known reports include: New York State Department of Environmental Conservation and Seatuck Research Foundation. 1993. 1990-1991 Long Island colonial waterbird and piping plover survey, Volumes 1 and 2. Stony Brook, NY; Sommers and Meskill 1994, Sommers et al. 1996, Sommers and Alfieri 1997)

New York State Department of Environmental Conservation. 1996. 1995 Long Island colonial waterbird and piping plover survey. Division of Fish and Wildlife, Region 1, Stony Brook, NY.

New York State Department of the State, Division of Coastal Resources and USFWS, Southern New England-New York Bight Coastal Ecosystems Program. 1998. South Shore Estuary Reserve Waterfowl Draft Technical Report.

Nielsen, M.G. 2002. Water Budget for, and nitrogen loads to, Northeast Creek, Bar Harbor, Maine. U.S. Geological Survey Water-Resources Investigations Report 02-4000 32p.

Niles, L.J., K. Clark, and S. Paul. 1994. Comprehensive management plan for shorebirds on Delaware Bay. New Jersey State Endangered and Nongame Species Program, Division of Fish, Game and Wildlife, Trenton, NJ.

North American Waterfowl Management Plan. 1994. 1994 update to the North American waterfowl management plan: expanding the commitment.

NPS 1991. Jamaica Bay Fisheries Survey: 1985-1986 and 1988-1989. Gateway National Recreation Area Division of Natural Resources and Compliance.

NPS 2000a. National Park Service Annual Report for Assateague Island National Seashore's Water Quality Monitoring Program: chemical and physical properties.

NPS 2000b. Gateway National Recreation Area 2000 Water Quality Sampling Program. National Park Service, Gateway National Recreation Area Division of Natural Resources. 58pp.

NPS 2001. Final Report of the Jamaica Bay Blue Ribbon Panel on marsh Loss and Coastal Sea Level Rise: a Future Agenda for Mitigation and Pilot Investigations. Gateway National Recreation Area.

NRC (National Research Council). 1990. Managing Troubled Waters: the Role of Marine Environmental Monitoring. Committee on a Systems Assignment of the Marine Environment Monitoring, Marine Board, Commission on Engineering and Technical Systems, National Research Council, National Academy Press, Washington DC. 125 pp.

NY/NJ HEP 1996. New York-New Jersey Harbor Estuary Program: including the Bight Restoration Plan, Final Comprehensive Conservation and Management Plan. 280 pp.

NYSDEC. Undated. Brant surveys. Bureau of Wildlife, Stony Brook , NY

Parsons, K.C. and A.C. McColpin. 1993. Aquatic birds of New York Harbor: 1993 management report. Submitted to New York City Audubon Society, New York, NY.

Perry, M. C., and A. S. Deller. 1995. Waterfowl population trends in the Chesapeake Bay area. Pages 490-504 In Paula Hill and Steve Nelson, editors. Proceedings of the 1994 Chesapeake Research

Conference. Toward a Sustainable Watershed: The Chesapeake Experiment. CRC Publication No. 149. Chesapeake Research Consortium, Edgewater, MD. 724 pp.

Peterjohn, B. G., and J. R. Sauer. 1993. North American Breeding Bird Survey annual summary 1990-1991. Bird Populations 1:1-15.

Pfister, C. and B.A. Harrington. 1992. The impact of human disturbance on shorebirds at a migration staging area. Biological Conservation 60:115-126.

Pluhowski, E.J., and I.H. Kantrowitz, I.H., 1964, Hydrology of the Babylon-Islip area, Suffolk County, Long Island, N.Y.: U.S. Geological Survey Water-Supply Paper1768, 119p.

Pouyot, R.V. and M.J. McDonald. The ecology and natural resources of New York City. Institute for Ecosystem Studies, Occasional paper #5, Millbrook, NY.

Powers, K.P. 1983. Pelagic distribution of marine birds off the northeastern United States. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-F/NEC-27. U.S. Department of Commerce, National Marine Fisheries Service, Woods Hole, MA. 201 p.

Procter, W. 1993. Biological Survey of the Mount Dessert Region. V:5 - Marine fauna: with description and places of capture to which is added a list of the Arachnida and other non-marine forms. Philadelphia, PA., The Wistar Institute of Anatomy.

Raposa, K.B. 1997. Factors affecting the structure of nekton communities in eelgrass beds: contiguous shoreline type; distance from shore; and vegetation biomass. MS Thesis, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI. 135p.

Raposa, K.B. and C.T. Roman. 2001. Monitoring nekton in shallow estuarine habitats. U.S. Geological Survey Patuxent Wildlife Research Center, Coastal Research Station, Narragansett, RI 39pp.

Rex, A.C. and D.I. Taylor. 2000. Combined Work/Quality Assurance Project Plan for Water Quality Monitoring and Combined Sewer Overflow Receiving Water Monitoring in Boston Harbor and its Tributary Rivers 2000. Technical Report MS-067. Massachusetts Water Resources Authority, Boston, MA.

Robbins, C.S. 1970. Recommendations for an international standard for a mapping method in bird census work. Aud. Field Notes 24:723-726.

Robbins, C.S., D.K. Dawson, and B.A. Dowell. 1989. Habitat area requirements of breeding forest birds of the Middle Atlantic States. Wildlife Monographs 103:1-34.

Roman, C. T., N. Jaworski, F.T. Short, S. Findlay and R.S. Warren. 2000. Estuaries of the Northeastern United States: habitat and land use signatures. Estuaries 23: 743-746.

Roman, C.T. and N.E. Barrett. 1999. Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore. USGS Patuxent Wildlife Research Center, University of Rhode Island. 59p.

Roman, C.T. and N.E. Barrett. 1999. Conceptual framework for the development of long-term monitoring protocols at Cape Cod National Seashore. U.S. Geological Survey Patuxent Wildlife Research Center, Cooperative National Park Studies Unit. Narragansett, RI 59pp.

Roman, C.T., M.J. James-Pirri, J. F. Heltshe. 2001. Monitoring Salt Marsh Vegetation: Part of a series of monitoring protocols for the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore. USGS Patuxent Wildlife Research Center, Coastal Research Field Station, University of Rhode Island, Narragansett, RI 02882.

Roman, C.T., K.B. Raposa, S.C. Adamowicz, M.J. James-Pirri, and J.G. Catena. IN PRESS. Quantifying vegetation and nekton response to tidal restoration of a New England salt marsh. Restoration Ecology.

Rosenberg, K.V. and J.V. Wells. 1995. Importance of geographic areas to Neotropical migrant birds in the Northeast. Report submitted to U.S. Fish and Wildlife Service Region 5, Hadley, MA.

Sabin, Walton B. and Bryan L. Swift. New York State Federation Waterfowl Count, January 2000. The Kingbird. Volume 50 Number 4, December 2000.

Sauer, J.R. and S. Droege. 1992. Geographic patterns in population trends of Neotropical migrants in North America. In J.M. Hagan III and D.W. Johnston (eds.) Ecology and Conservation of Neotropical migrant landbirds, pp. 26-42. (Papers from the symposium hosted by Manomet Bird Observatory, Dec. 6-9, Woods Hole, MA). Smithsonian Institution Press, Washington, D.C.

Schlenk, C. and W.M. Wise. 1999. Draft summary report: South Shore Estuary Reserve (SSER) water quality workshop. September 26, 1996. Cited in SSER 2000.

Schneider, K.J. and D.M. Pence (eds.) 1992. Migratory nongame birds of management concern in the Northeast. U.S. Department of the Interior, Fish and Wildlife Service, Newton Corner, MA.

Serie, J.R. and R.V. Raftovich, Jr. 2000. Atlantic Flyway Midwinter Waterfowl Survey 2000-Final Report. U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Laurel, MD 20708. 3p.

Sinnon, A. 1969. Groundwater resources of the Northern Neck Peninsula, Virginia. Virginia Division of Mineral Resources, Bulletin 69:259-269.

Smith, C.R., D.M. Pence, and R.J. O'Connor. 1993. Status of Neotropical migrant birds in the Northeast: a preliminary assessment. In D. Finch and K Stangel (eds.) Status and management of Neotropical migrant birds. U.S. Forest Service, Gen. Tech. Report RM-229, Fort Collins, CO.

Spellerberg, I. 1991. Monitoring Ecological Change. Cambridge University Press, Cambridge. 334p.

SSER 2000. Development of a coordinated monitoring strategy for the South Shore Estuary Reserve (SSER) Comprehensive Management Plan. SSER Council and NY Department of State, Division of Coastal Resources.

SSER 2001. Long Island South Shore Estuary Reserve Draft Comprehensive Management Plan. South Shore Estuary Reserve Council.

Suffolk County 1999. South Shore Estuary Reserve, Suffolk County surface water quality monitoring report, 1977-1977, Volume II, data. Suffolk County Department of Health Services, Division of Environmental Quality, Office of Ecology, Bureau of Marine Resources. 235 p.

Taylor, D.I. 2001. Comparison of water quality in Boston Harbor before and after inter-island transfer. Boston: Massachusetts Water Resources Authority. Report ENQUAD 2001-09 014p. trends. U.S. Fish Wildl. Serv. Biol. Rep. 90(1).

U.S. Department of the Interior and Environment Canada. 1986. North American waterfowl management plan. A strategy for cooperation.

U.S. Fish and Wildlife Service. 1973-1995. Mid-winter waterfowl survey - Atlantic Flyway data. Office of Migratory Bird Management, Laurel, MD.

U.S. Fish and Wildlife Service. 1989. North American waterfowl management plan: South Shore Mainland marshes focus area plan (Long Island), Atlantic Coast joint venture. Region 5, Newton Corner, MA.

U.S. Fish and Wildlife Service. 1989. Roseate tern (Sterna dougallii) recovery plan, northeastern population. Region 5, Newton Corner, MA.

U.S. Fish and Wildlife Service. 1995. Piping plover (Charadrius melodus) Atlantic coast population revised recovery plan, technical/agency draft. Region 5, Hadley, MA.

U.S. Fish and Wildlife Service. Undated. North American waterfowl management plan Atlantic coast joint venture.

U.S. Fish and Wildlife Service: National Atlas of Coastal Waterbird Colonies in the Contiguous United States:1976-1982. Covered the Atlantic coast of the northeastern United States (including Long Island). Known reports include: (Erwin and Korschgen 1979) for 1977 atlas; 1984-1985 (Andrews 1990);1994-1996 (USFWS). ?? locations in GATE.

USFWS (U.S. Fish and Wildlife Service). 1965. Progress report on waterfowl uses, related to Fire Island Cooperative Beach Erosion Control Project, Montauk Point to Fire Island Inlet, Long

Island, New York, Segment II - Moriches Bay Region. Report to U.S. Army Corps of Engineers.

USFWS (U.S. Fish and Wildlife Service). 1969a. Progress report on waterfowl uses, related to Fire Island Cooperative Beach Erosion Control Project, Montauk Point to Fire Island Inlet, Long Island, New York, Segment I - Great South Bay Region. Report to U.S. Army Corps of Engineers.

USFWS (U.S. Fish and Wildlife Service). 1969b. Progress report on waterfowl uses, related to Fire Island Cooperative Beach Erosion Control Project, Montauk Point to Fire Island Inlet, Long Island, New York, Segment III - Shinnecock Bay Region. Report to U.S. Army Corps of Engineers.

USFWS (U.S. Fish and Wildlife Service). 1973-2000. Mid-winter waterfowl survey - Atlantic Flyway data. Office of Migratory Bird Management, Laurel, MD.

USFWS. 1998. Atlantic coast colonial waterbird nesting data 1994-1996. USFWS Migratory Bird Office, Patuxent, MD.

VA 2000a. York River and Lower York Coastal Basins Tributary Nutrient Reduction Strategy. Commonwealth of Virginia, Secretary of Natural Resources , and Departments of Conservation and Recreation, Environmental Quality, and Chesapeake Bay Local Assistance . February 2000.

VA 2000b. Tributary Strategy Goals for Nutrient and Sediment Reduction in the James River. Commonwealth of Virginia, Secretary of Natural Resources, and Departments of Chesapeake Bay Local Assistance , Conservation and Recreation, and Environmental Quality. August 2000.

Veit, Richard R., and Wayne R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society, Lincoln, MA 01773. 514 p. 617-259-9500 [This includes some atlas maps, but the state atlas has not yet been published.]

Vickery, P. D., J. R. Herkert, F. L. Knopf, J. Ruth, and C. E. Keller. 1997. Grassland birds: an overview of threats and recommended management strategies. Proceedings Partners-in-Flight Conference, Cape May, New Jersey.

Wilde, F.D., L.J. Britton, C.V. Miller, and D.W. Kolpin, compilers. 2000. Effects of Animal Feeding Operations on Water Resources and the Environment -- Proceedings of the technical meeting, Fort Collins, Colorado, August 30-September 1, 1999. U.S. Geological Survey Open-File Report 00-204, 107p.